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Flynn

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(54) **ADJUSTABLE PEDAL CONTROLLER WITH OBSTRUCTION DETECTION**

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(73) Assignee: **Dura Global Technologies, Inc.**, Rochester Hills, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 507 days.

This patent is subject to a terminal disclaimer.

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(22) Filed: **Jan. 16, 2004**

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Related U.S. Application Data

(63) Continuation-in-part of application No. 09/748,666, filed on Dec. 22, 2000, now Pat. No. 6,739,212.

(51) **Int. Cl.**
G05G 1/14 (2006.01)

(52) **U.S. Cl.** **74/512**

(58) **Field of Classification Search** 74/512, 74/513, 560; 180/271, 315; 318/139, 432
See application file for complete search history.

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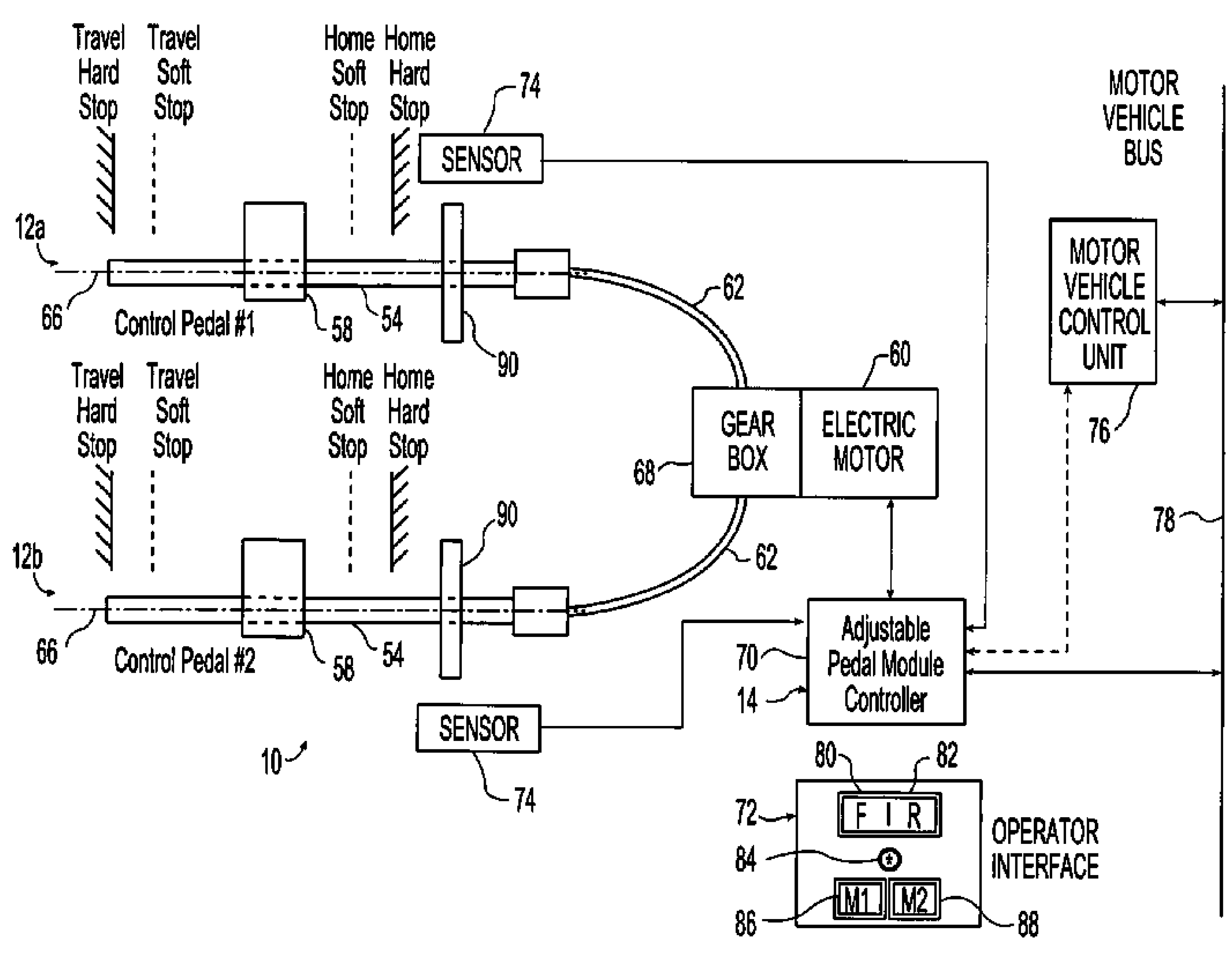
(57) **ABSTRACT**

An adjustable control pedal includes an upper arm, a lower arm, and a drive assembly operatively connected to the lower arm to selectively move the lower arm relative to the upper arm. The drive assembly includes a drive screw, a drive nut cooperating with the drive screw such that the drive nut travels along the drive screw upon rotation of the drive screw, and an electric motor to selectively rotate the drive screw. A hall-effect sensor is located adjacent the drive screw and cooperates with a ring magnet rotatable with the drive screw to detect motion information, including distance and velocity information, upon rotation of the drive screw. The controller determines stall conditions of the lower pedal arm between the limits of travel based on the velocity information received during movement of the lower pedal arm to reduce injury or damage resulting from engagement with obstructions.

19 Claims, 24 Drawing Sheets



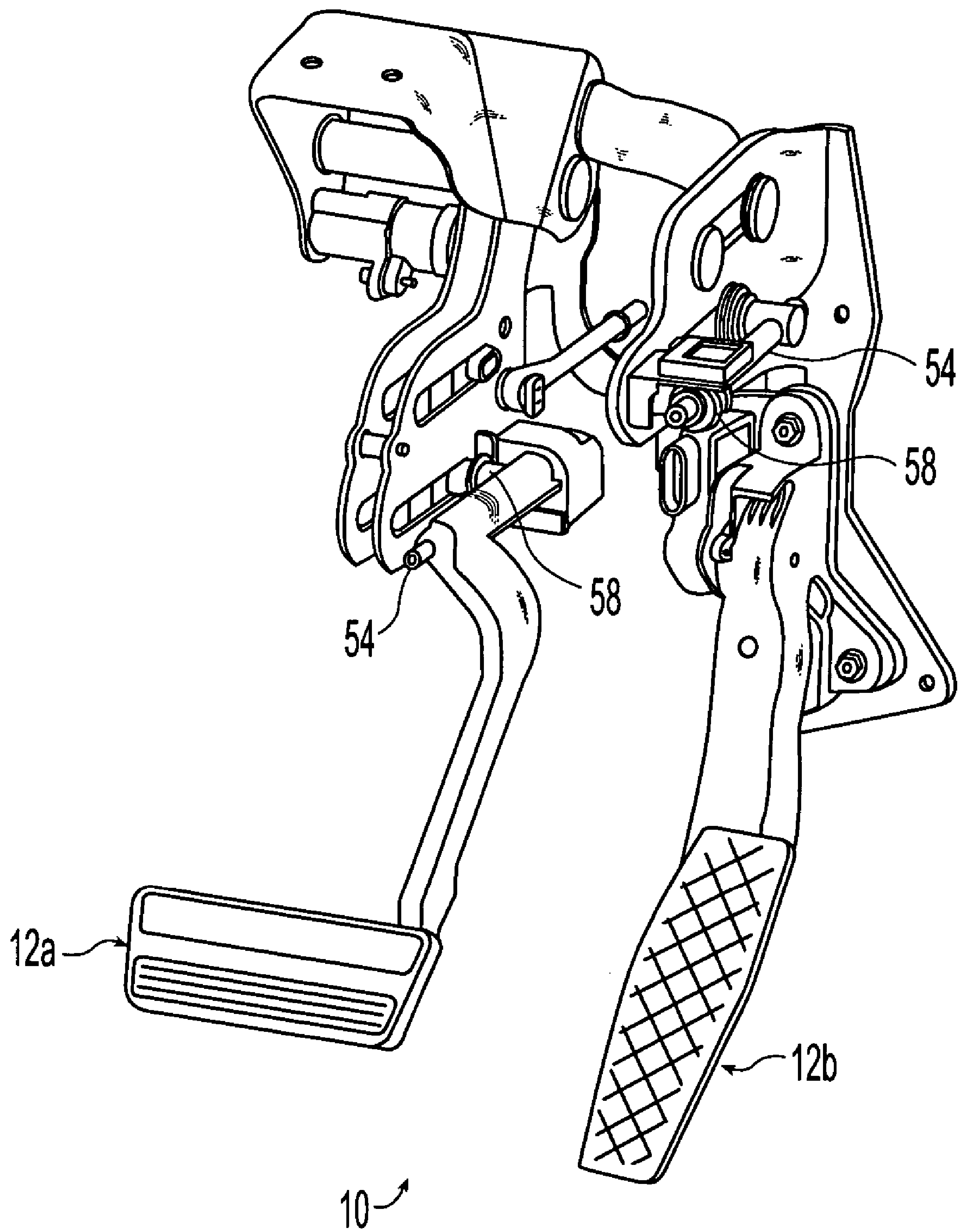


Fig. 1

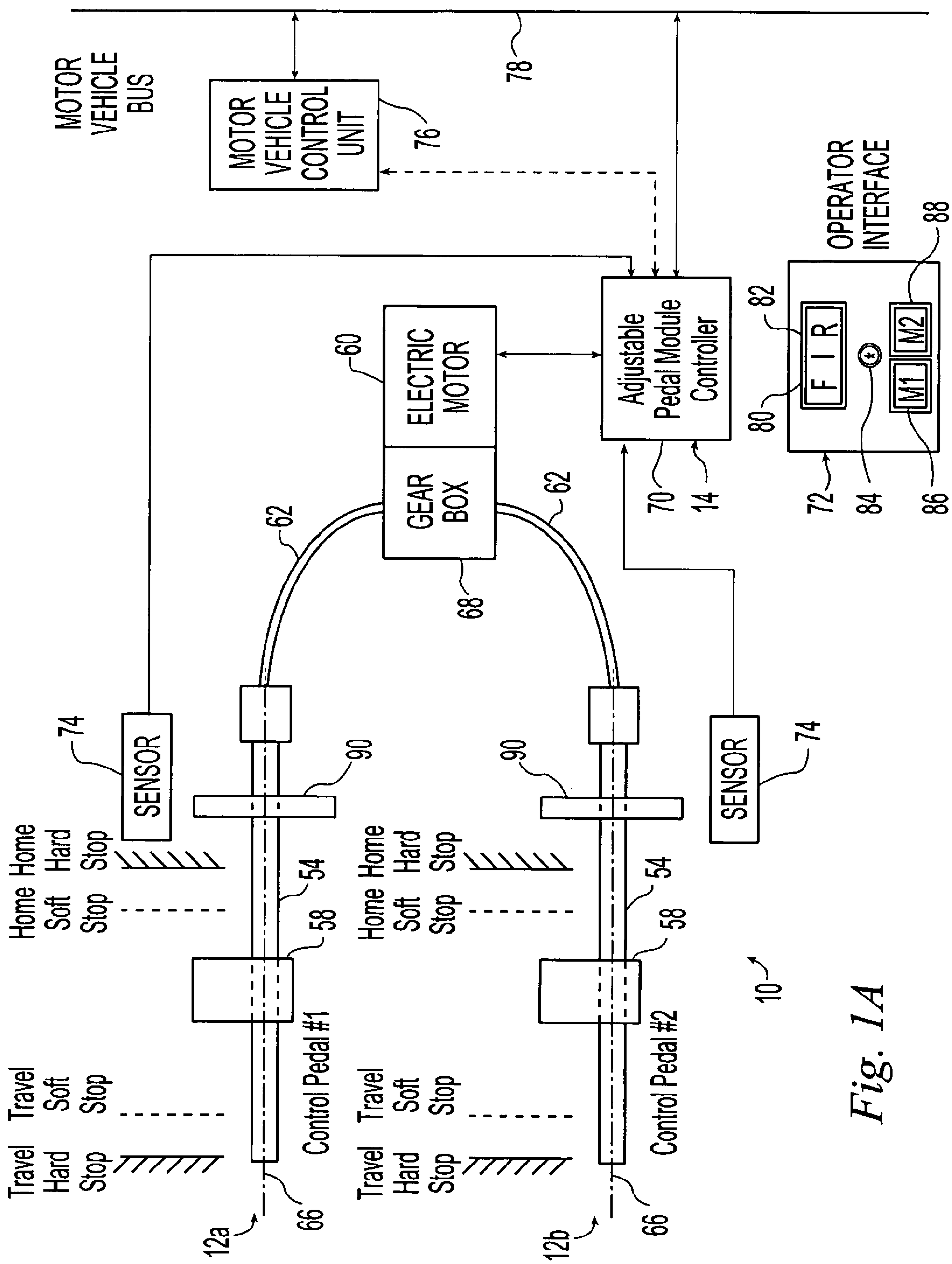

MOTOR VEHICLE BUS
78
MOTOR VEHICLE CONTROL UNIT
76
OPERATOR INTERFACE
88
82
F I R
M2
M1
80
72
84
86
Adjustable Pedal Module Controller
70
14
ELECTRIC MOTOR
60
GEAR BOX
68
62
62
SENSOR
74
SENSOR
74
90
90
Home Hard Stop
Home Soft Stop
54
58
54
58
Travel Soft Stop
Travel Hard Stop
Control Pedal #1
Control Pedal #2
66
66
12a
12b
10

Fig. 1A

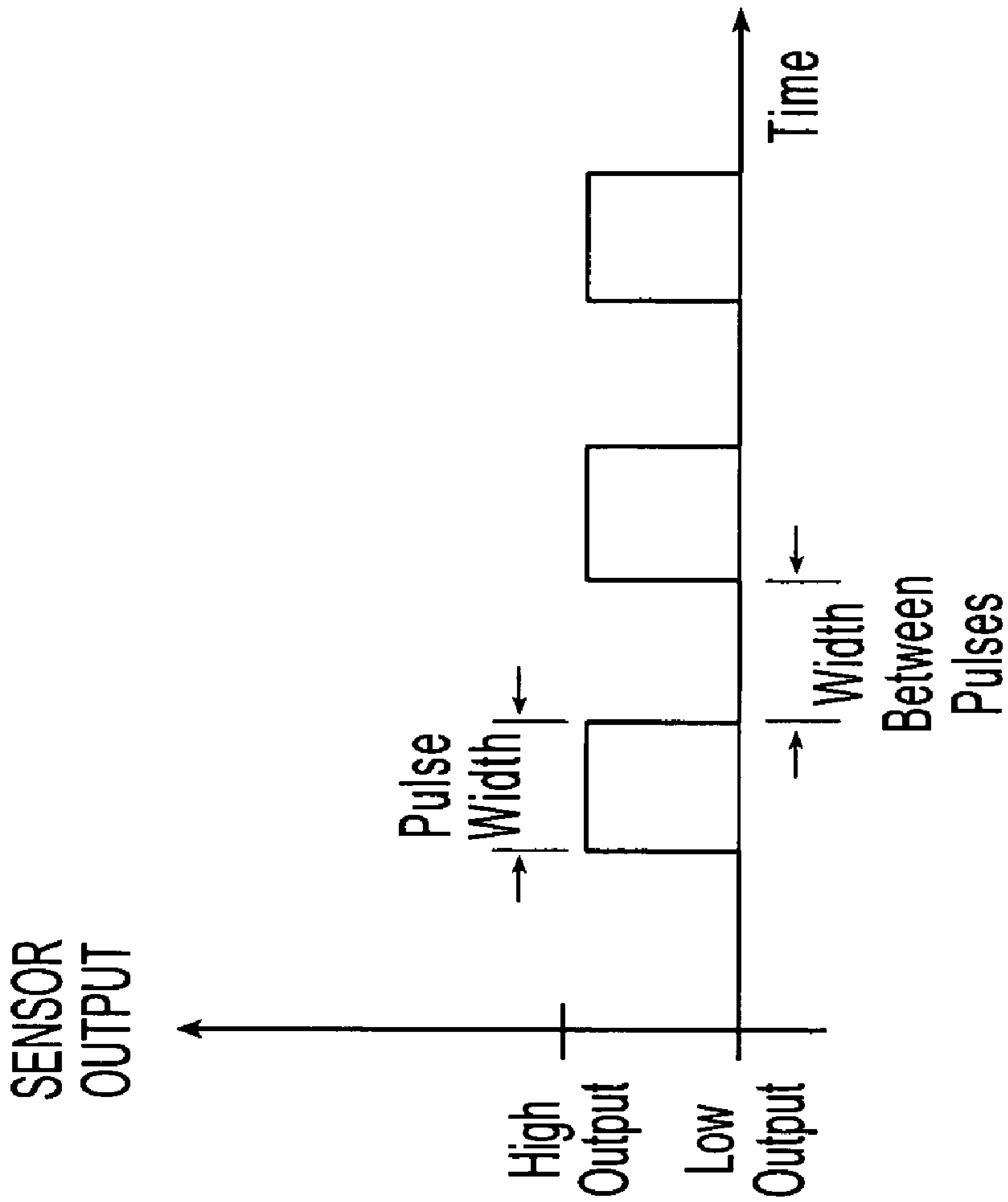

SENSOR
OUTPUT
Time
Pulse
Width
Width
Between
Pulses
High
Output
Low
Output

Fig. 1C

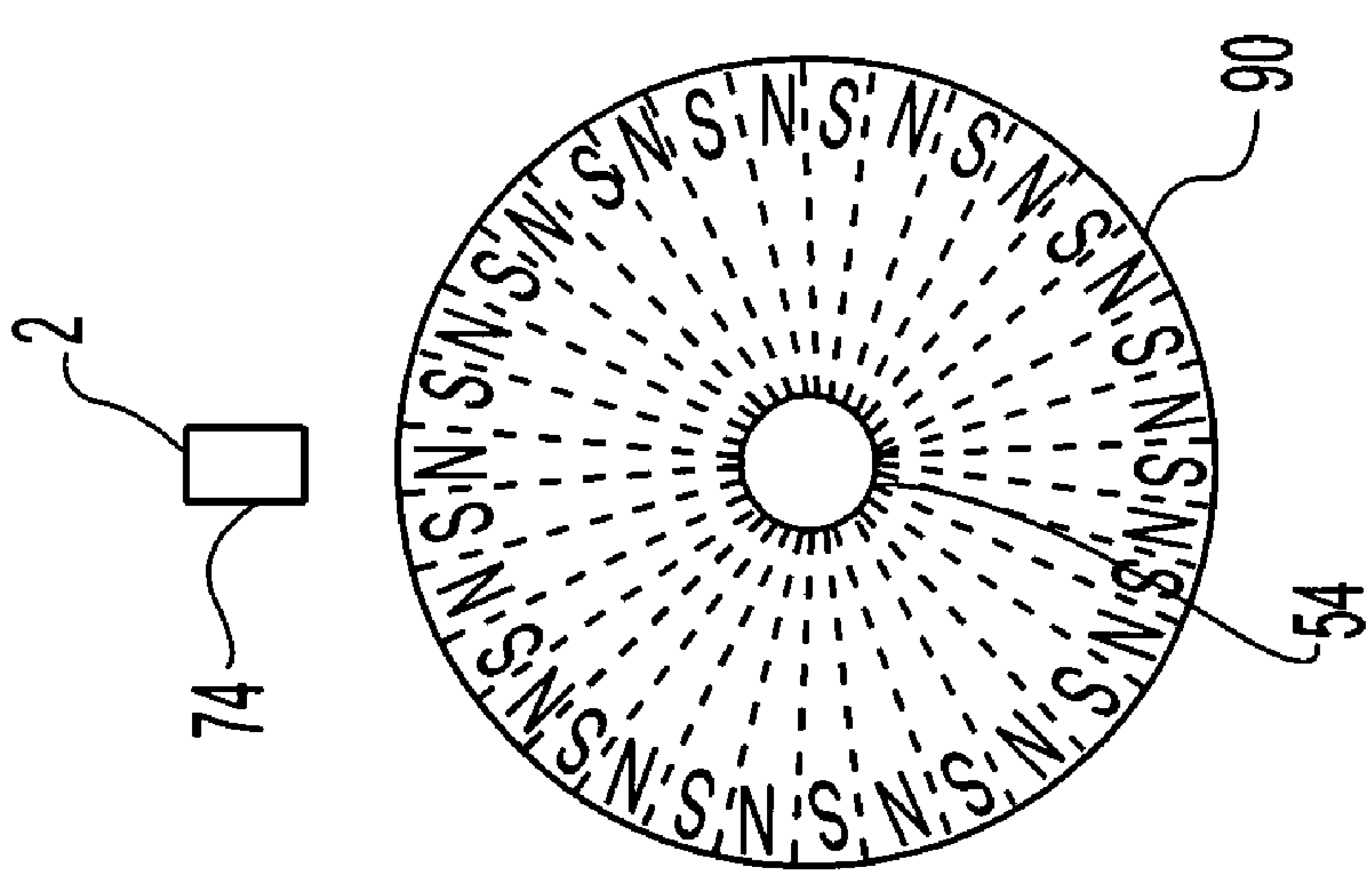

2
74
90
54

Fig. 1B

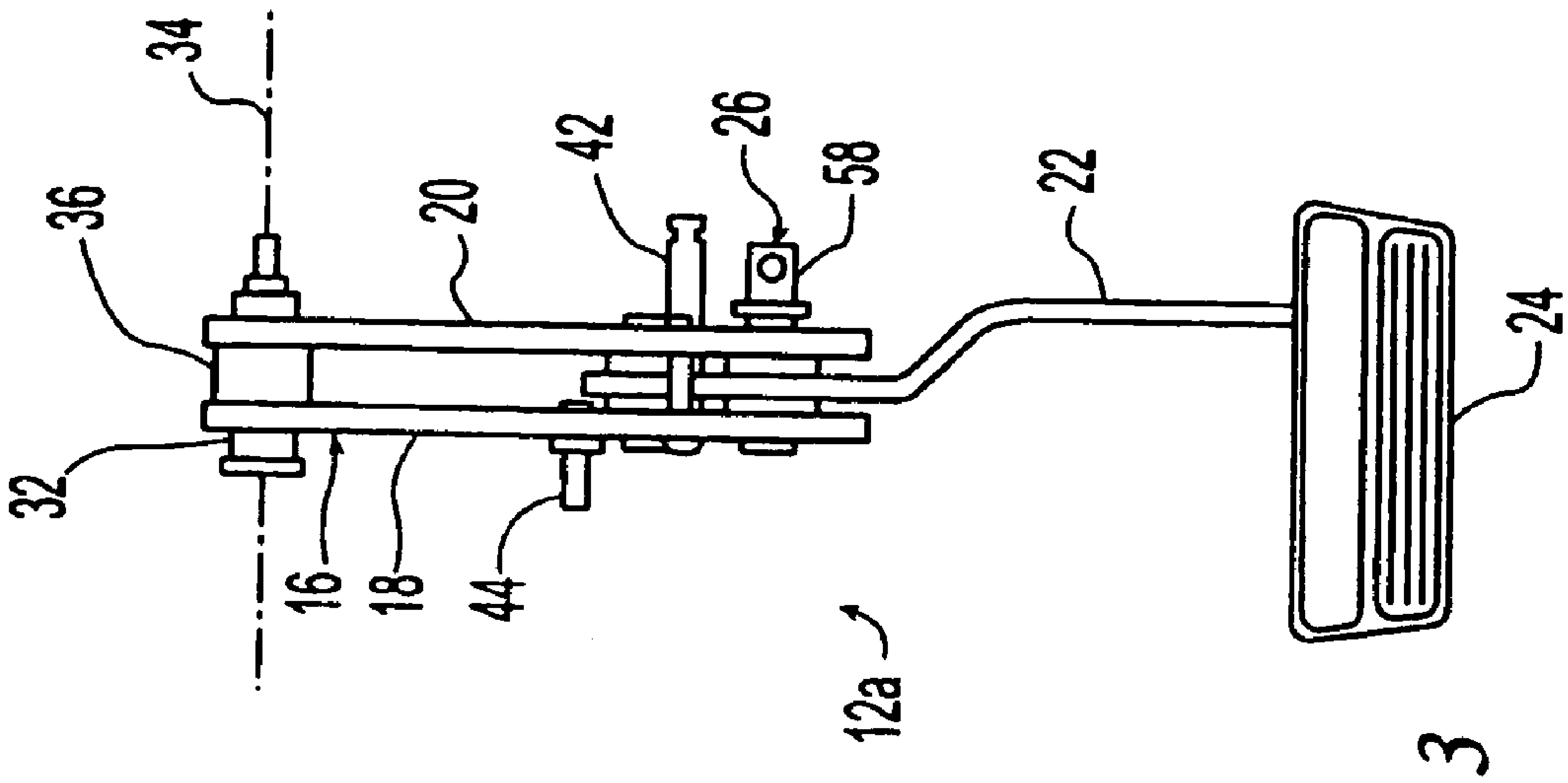
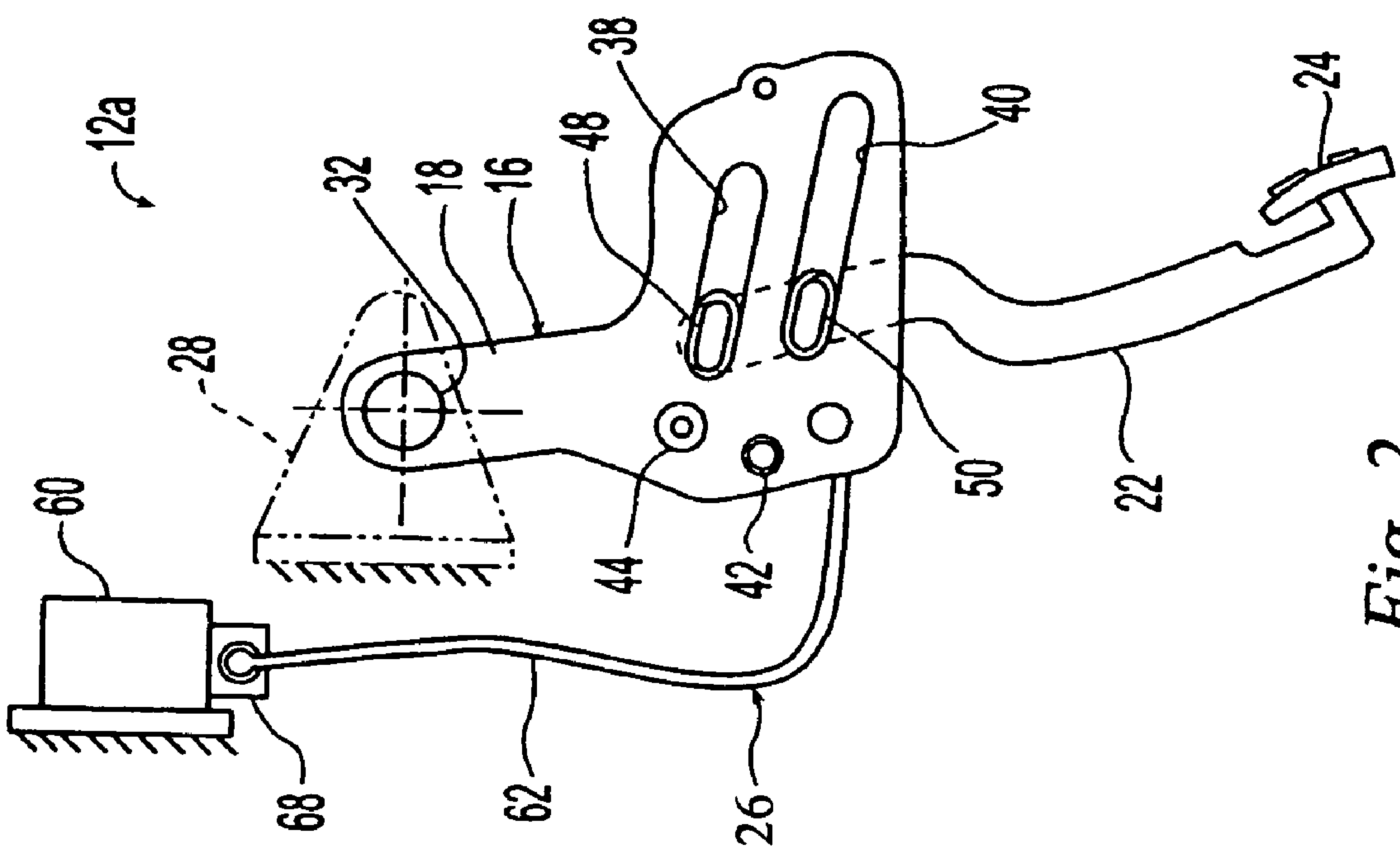

34
36
20
42
26
58
22
24
32
16
18
44
12a

Fig. 3


12a
38
48
32
18
16
40
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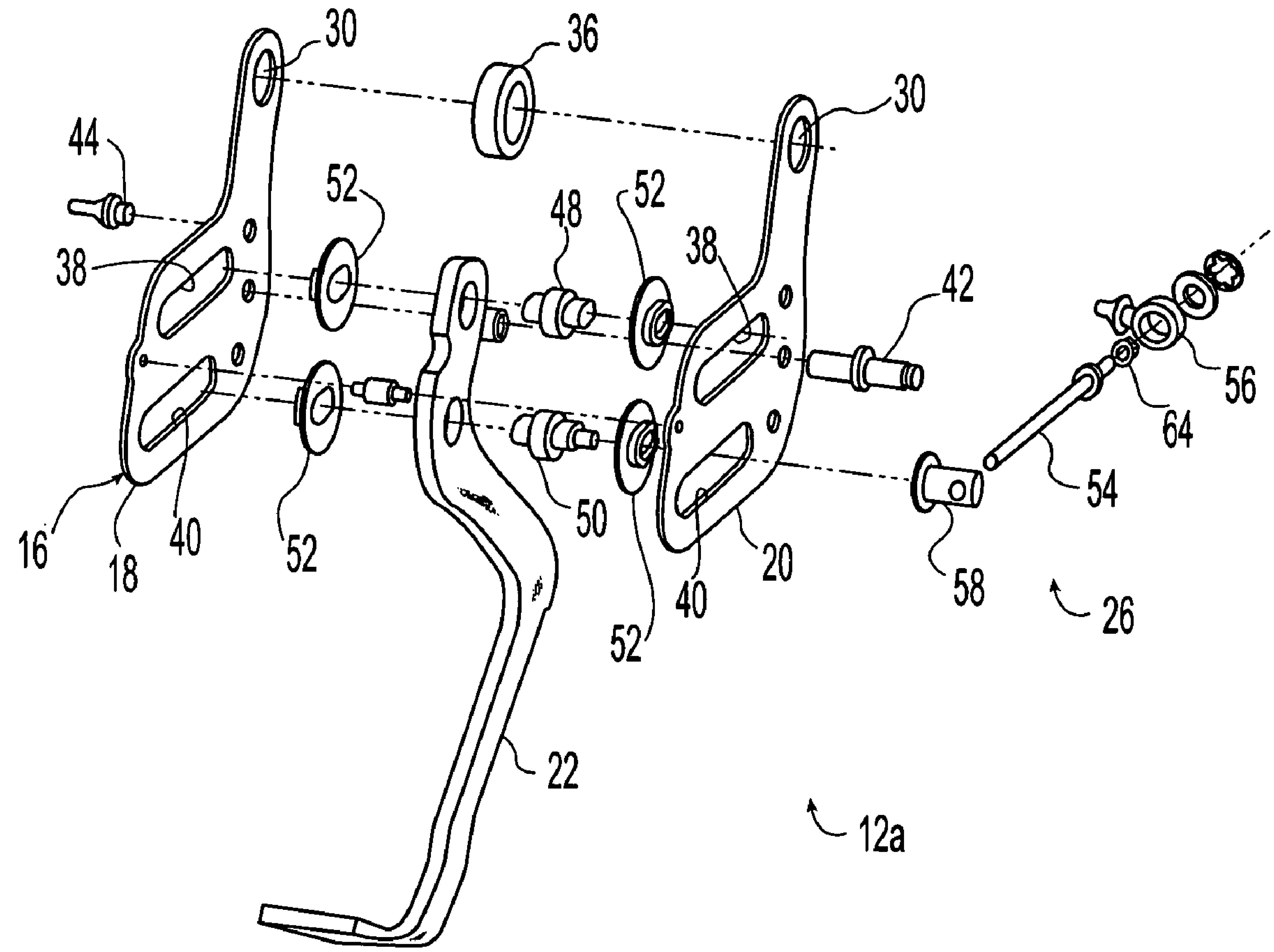
28
60
44
42
50
22
68
62
26

Fig. 2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64
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18
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58
26
40
52
22
12a

Fig. 4

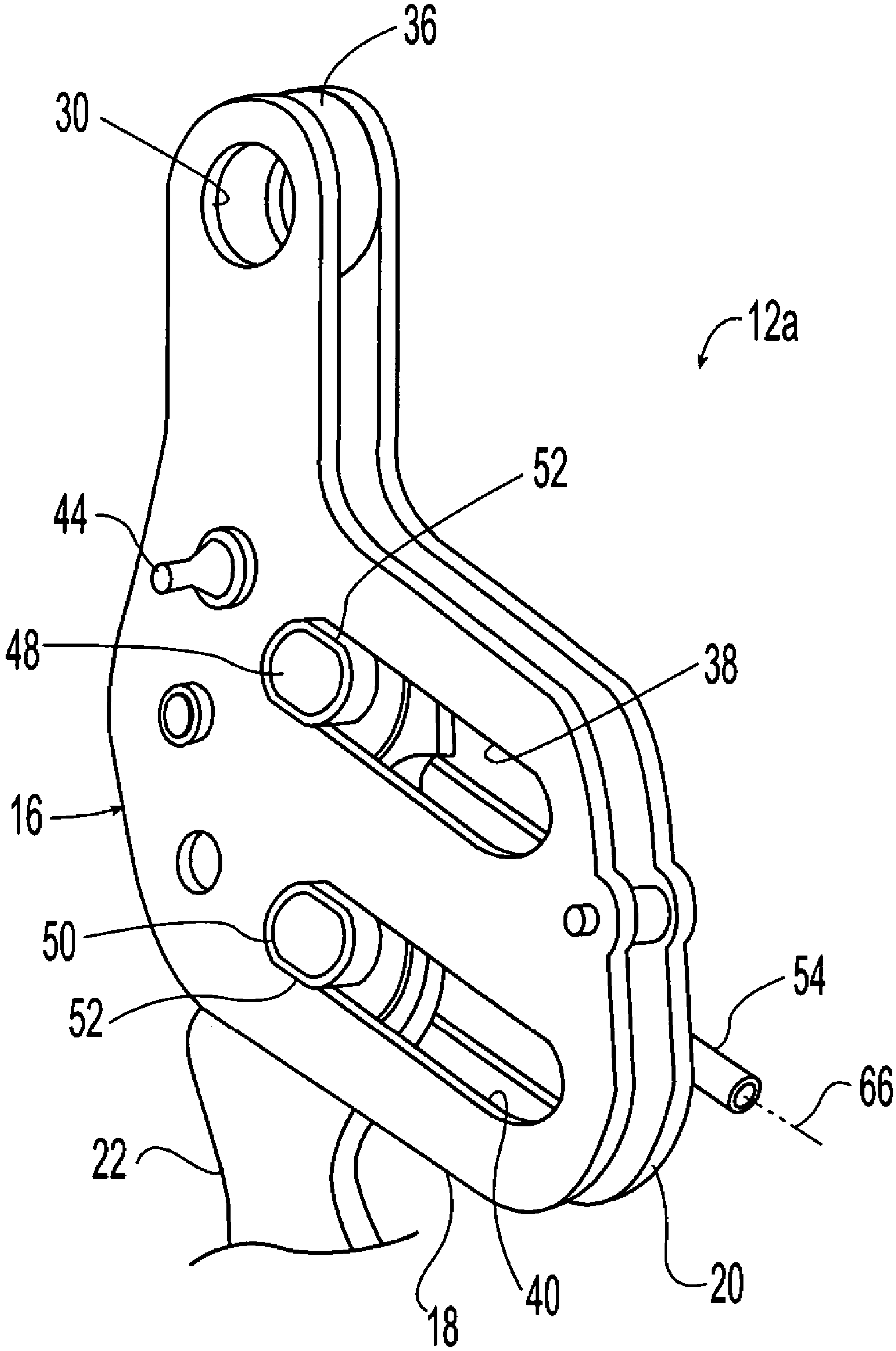


Fig. 5

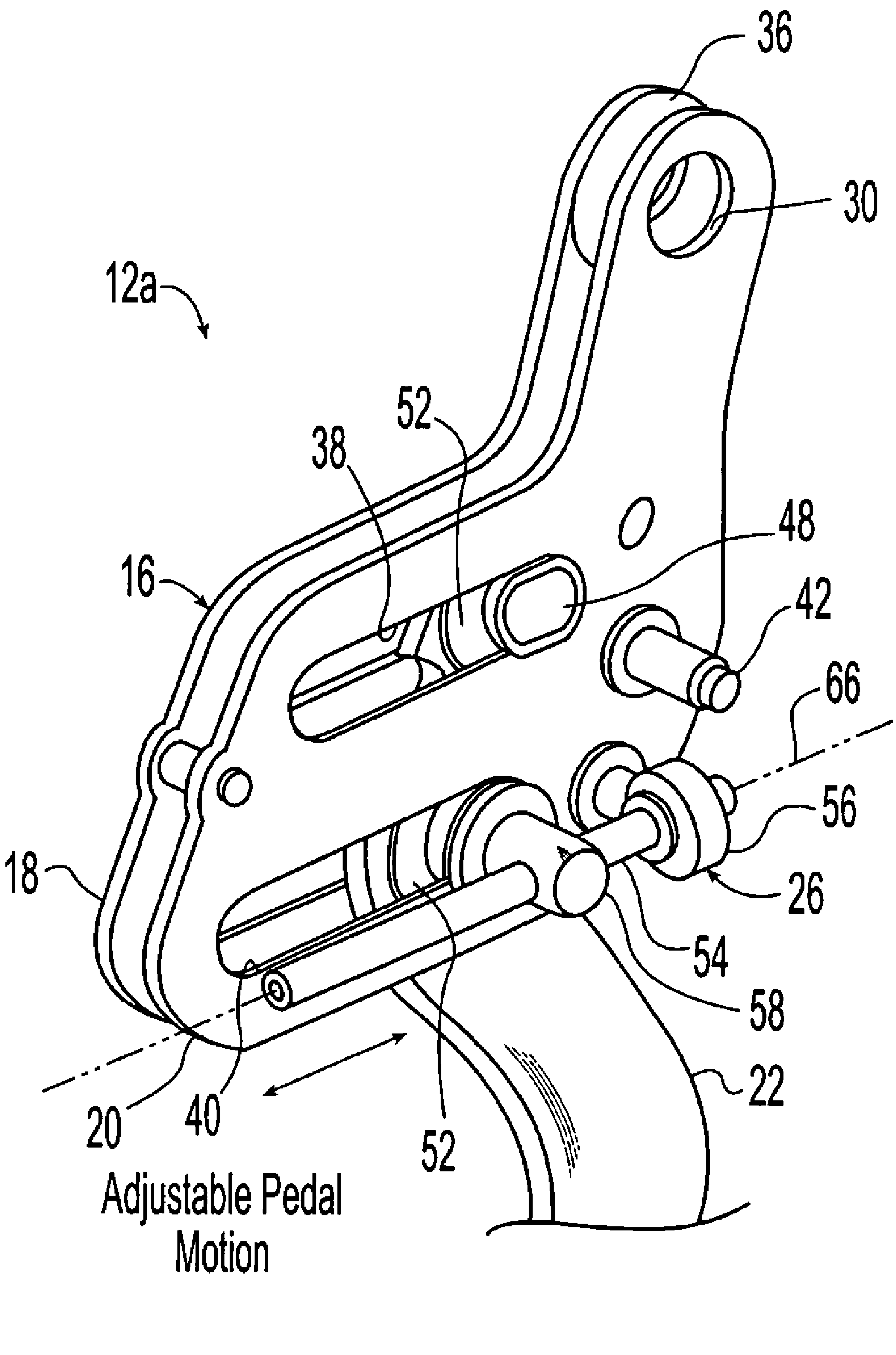
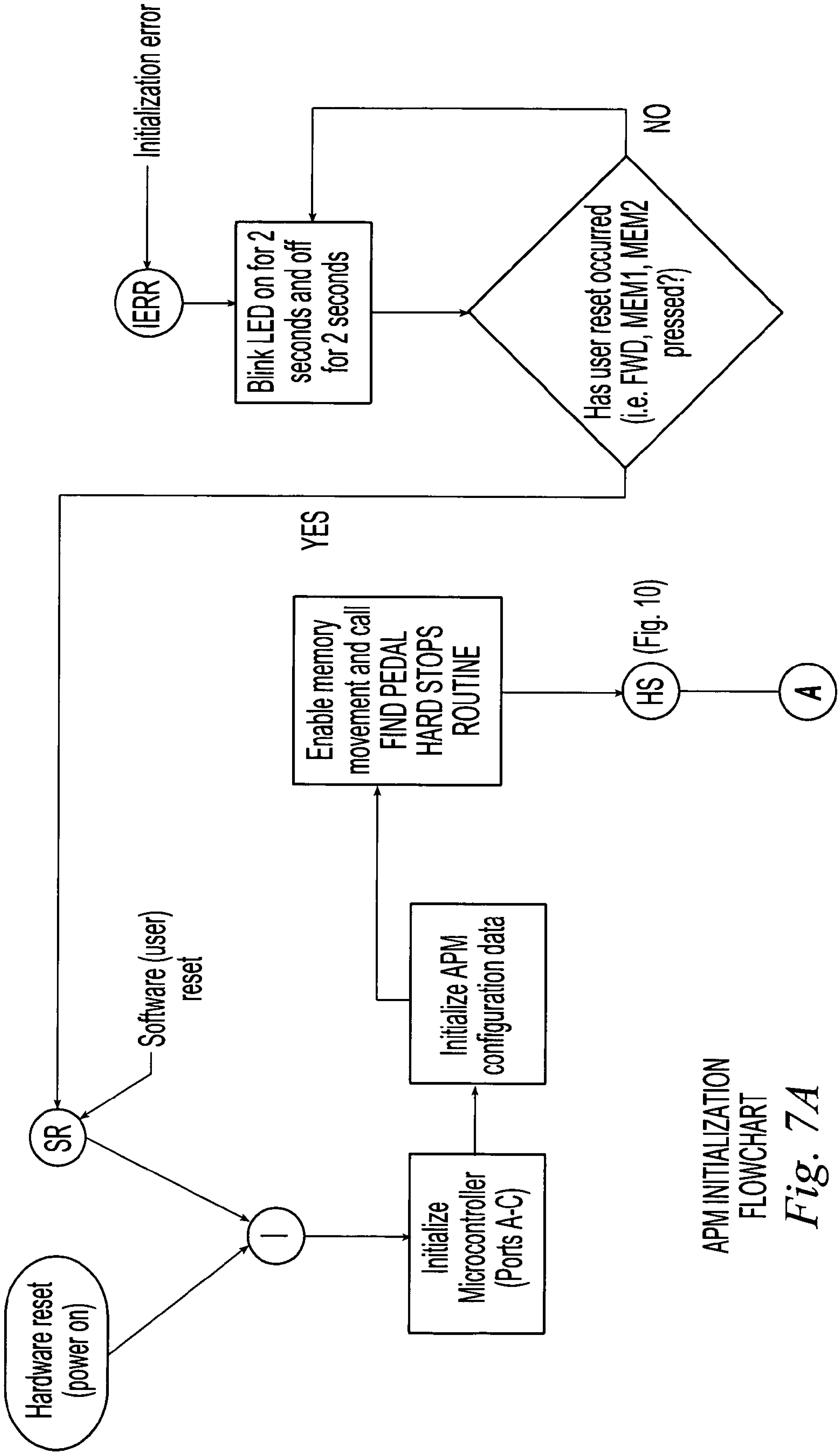

36
30
12a
52
38
48
16
42
66
56
18
26
54
58
22
20
40
52
Adjustable Pedal
Motion

Fig. 6

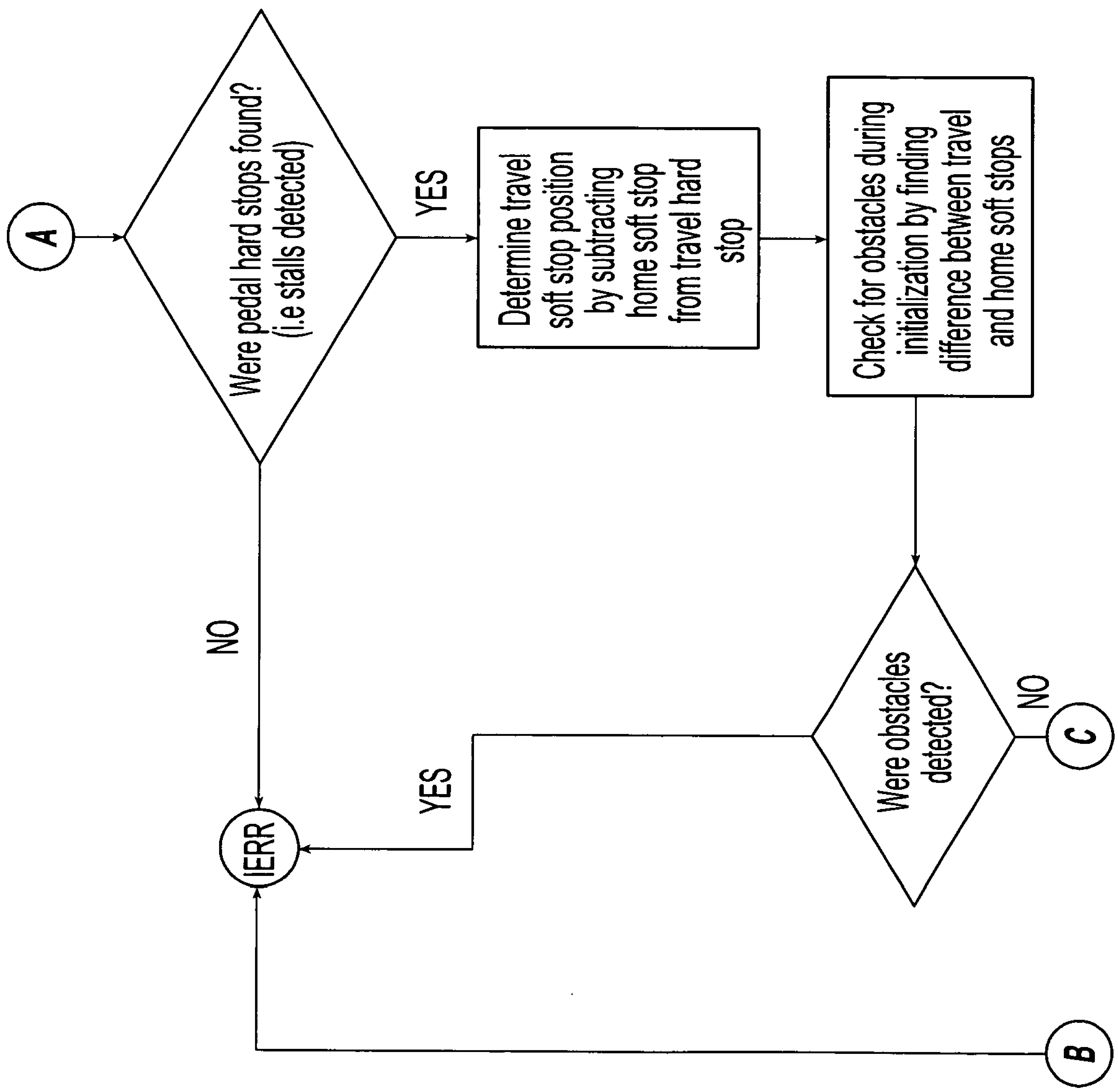


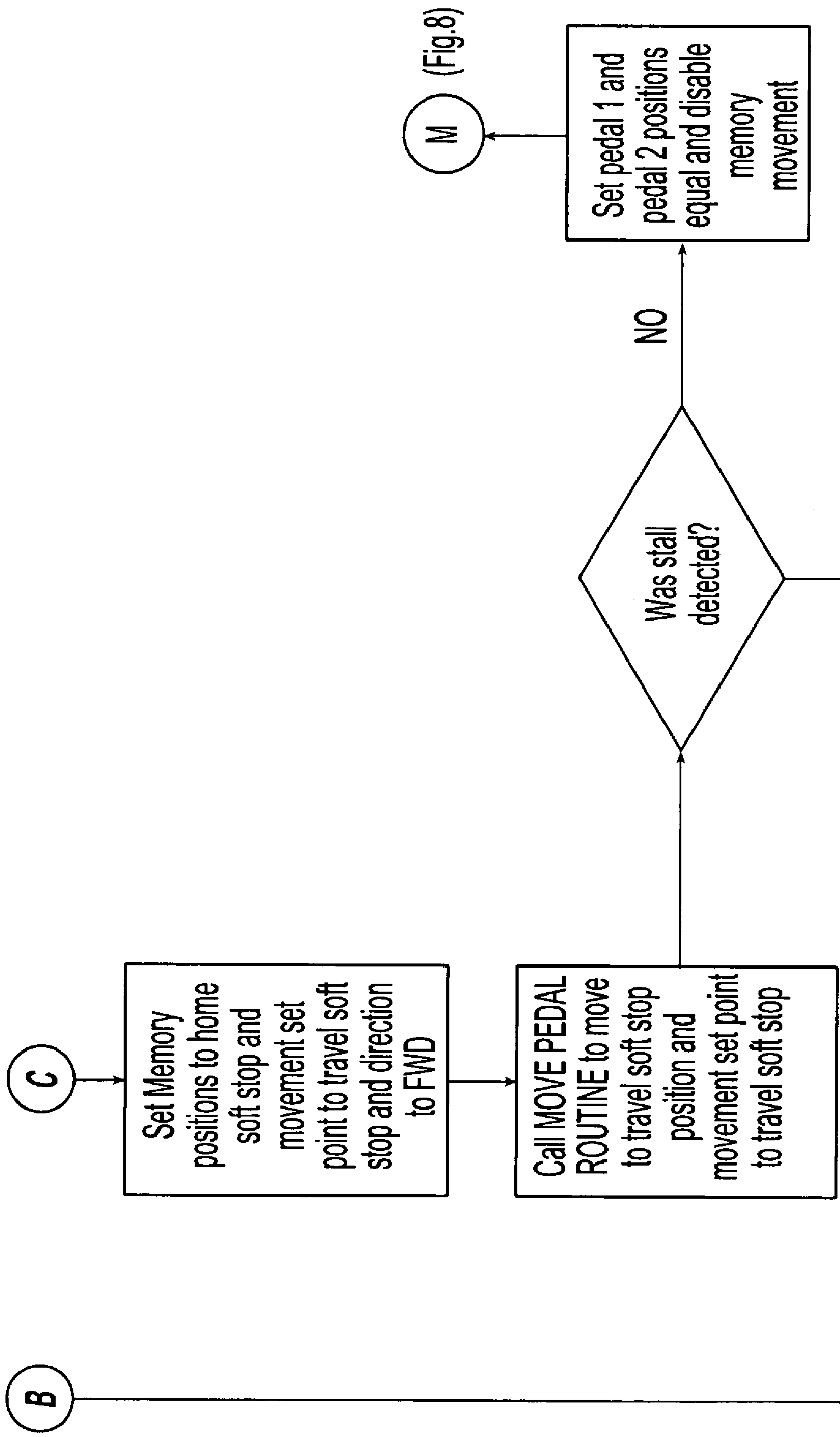
APM INITIALIZATION FLOWCHART

Fig. 7A

APM INITIALIZATION FLOWCHART

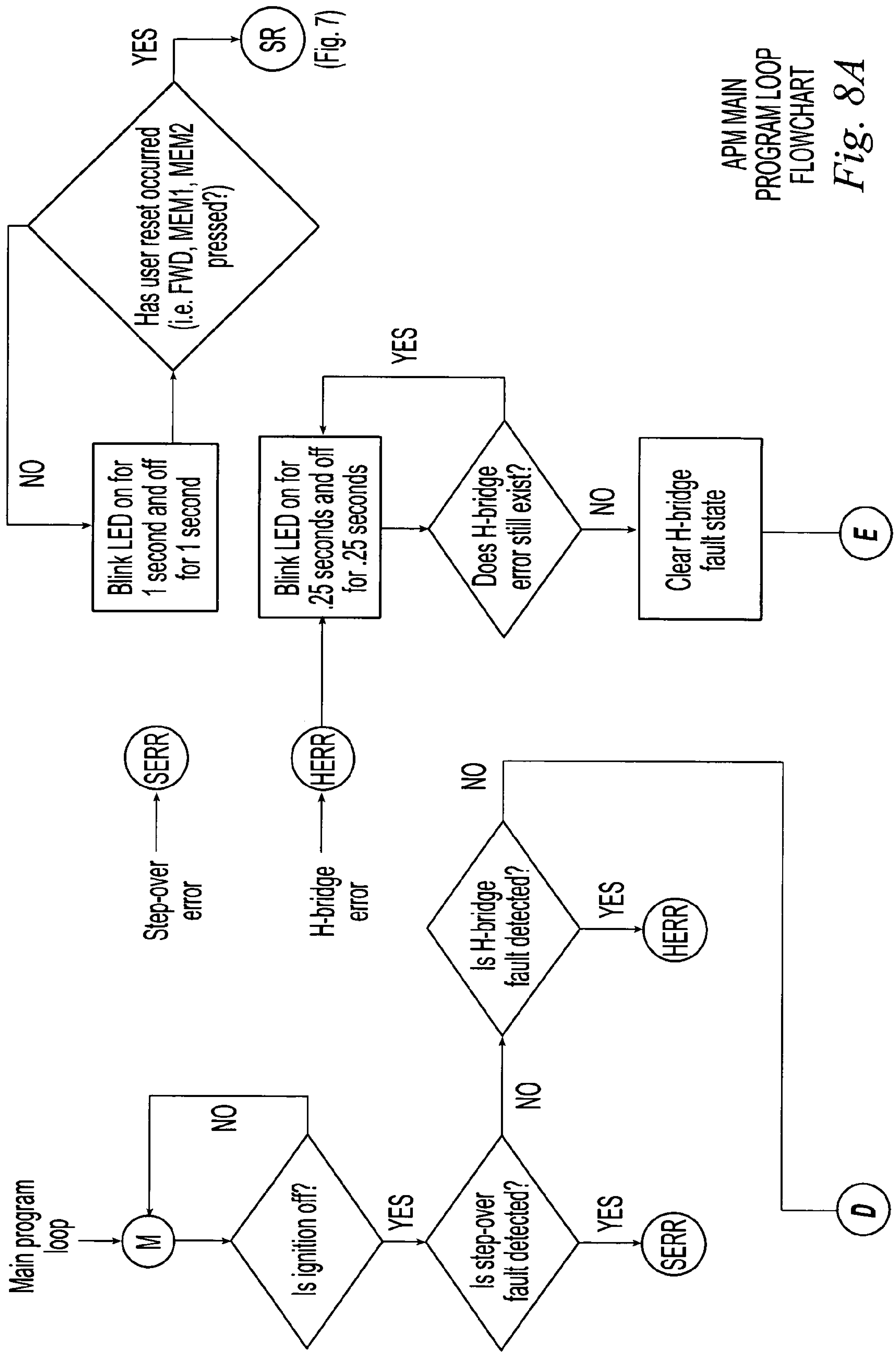
Fig. 7B





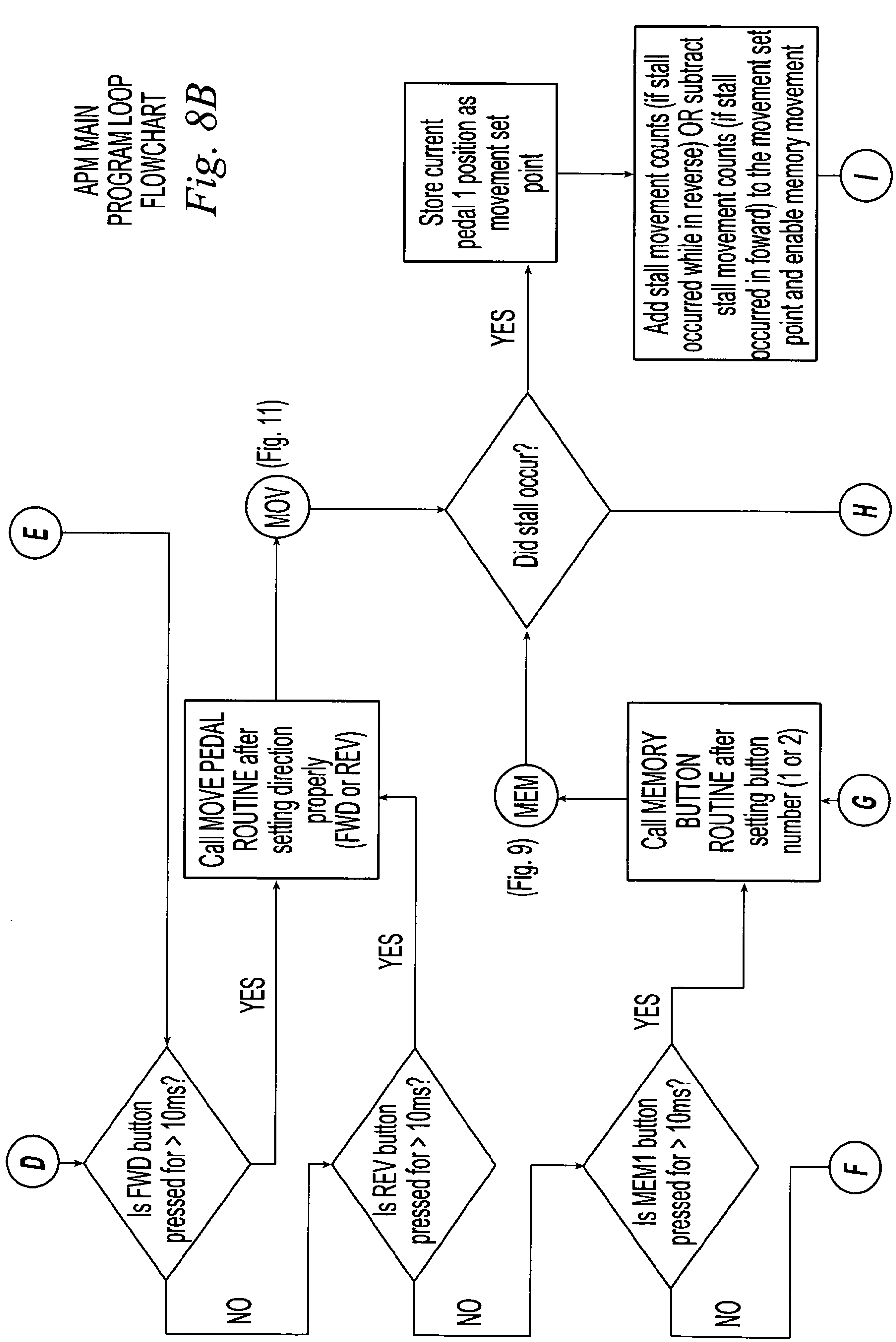
APM INITIALIZATION FLOWCHART

Fig. 7C



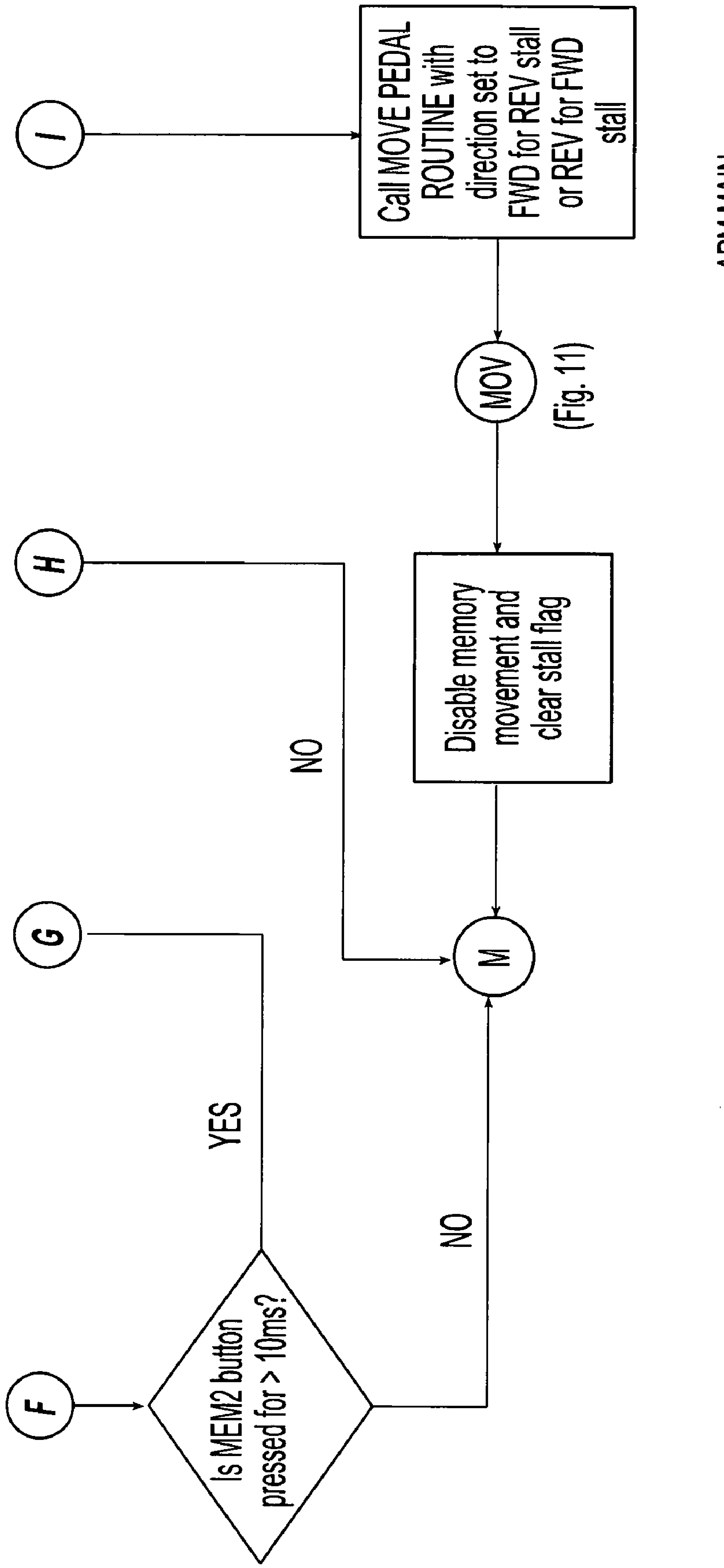
APM MAIN PROGRAM LOOP FLOWCHART

Fig. 8A



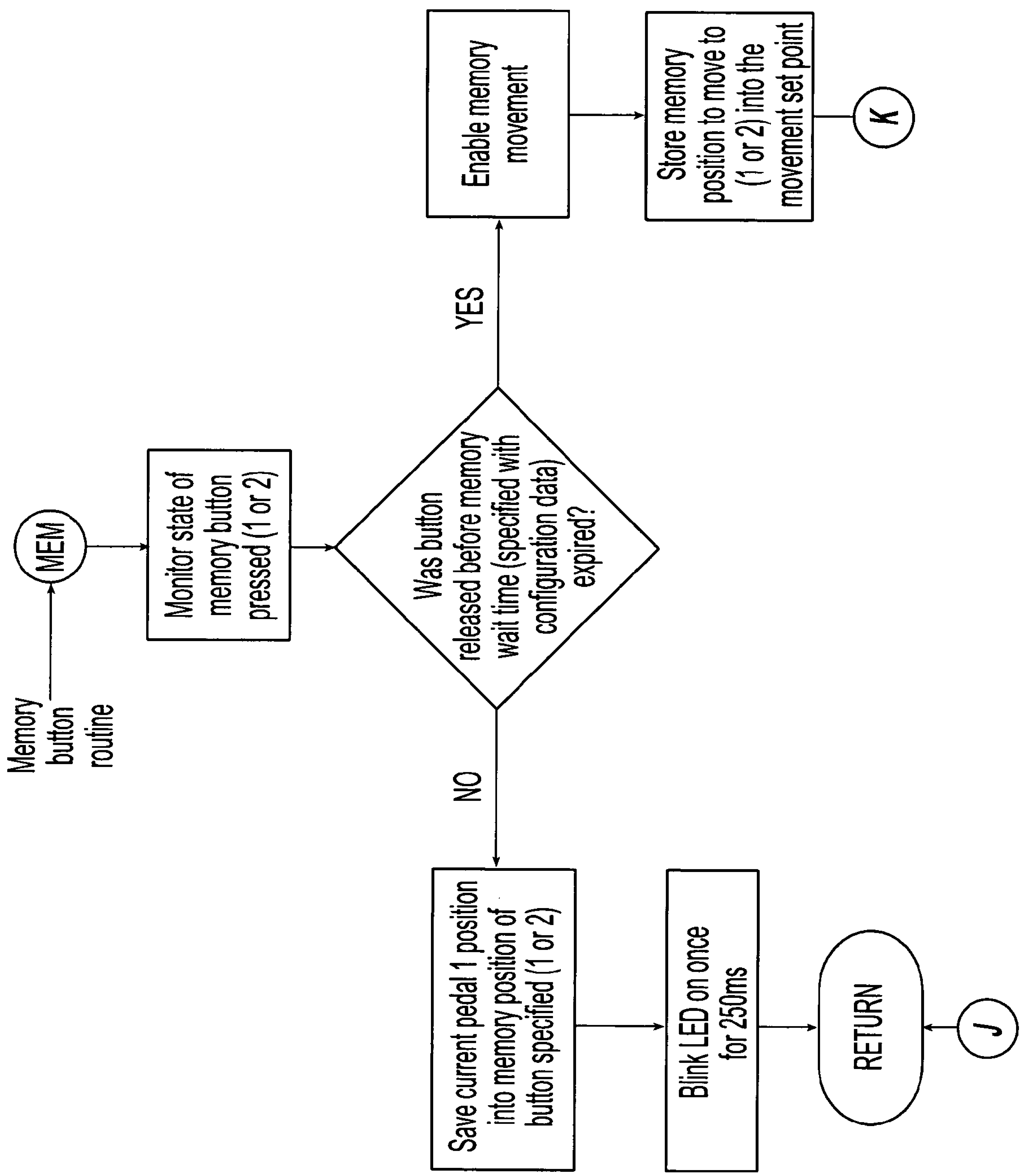
APM MAIN PROGRAM LOOP FLOWCHART

Fig. 8B



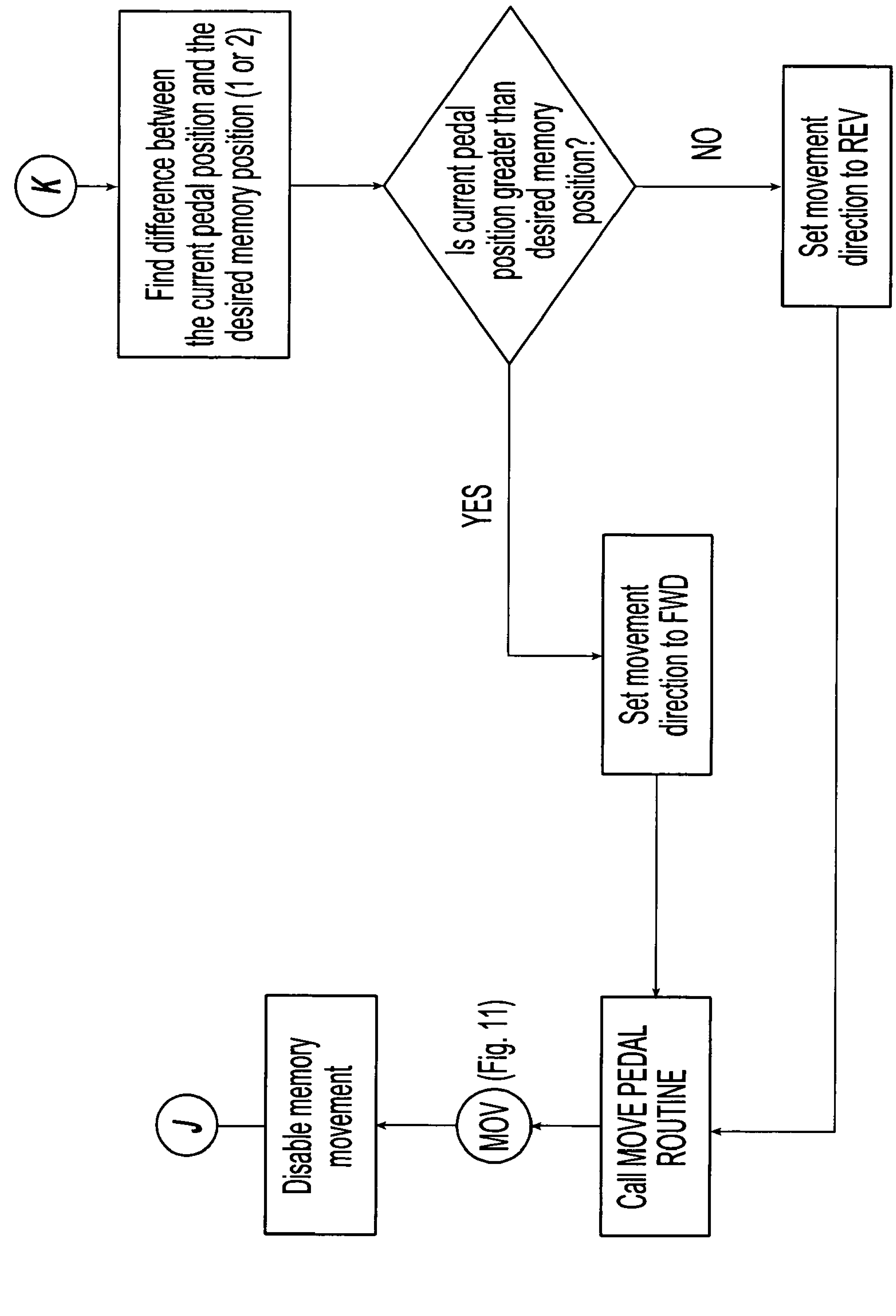
APM MAIN PROGRAM LOOP FLOWCHART

Fig. 8C



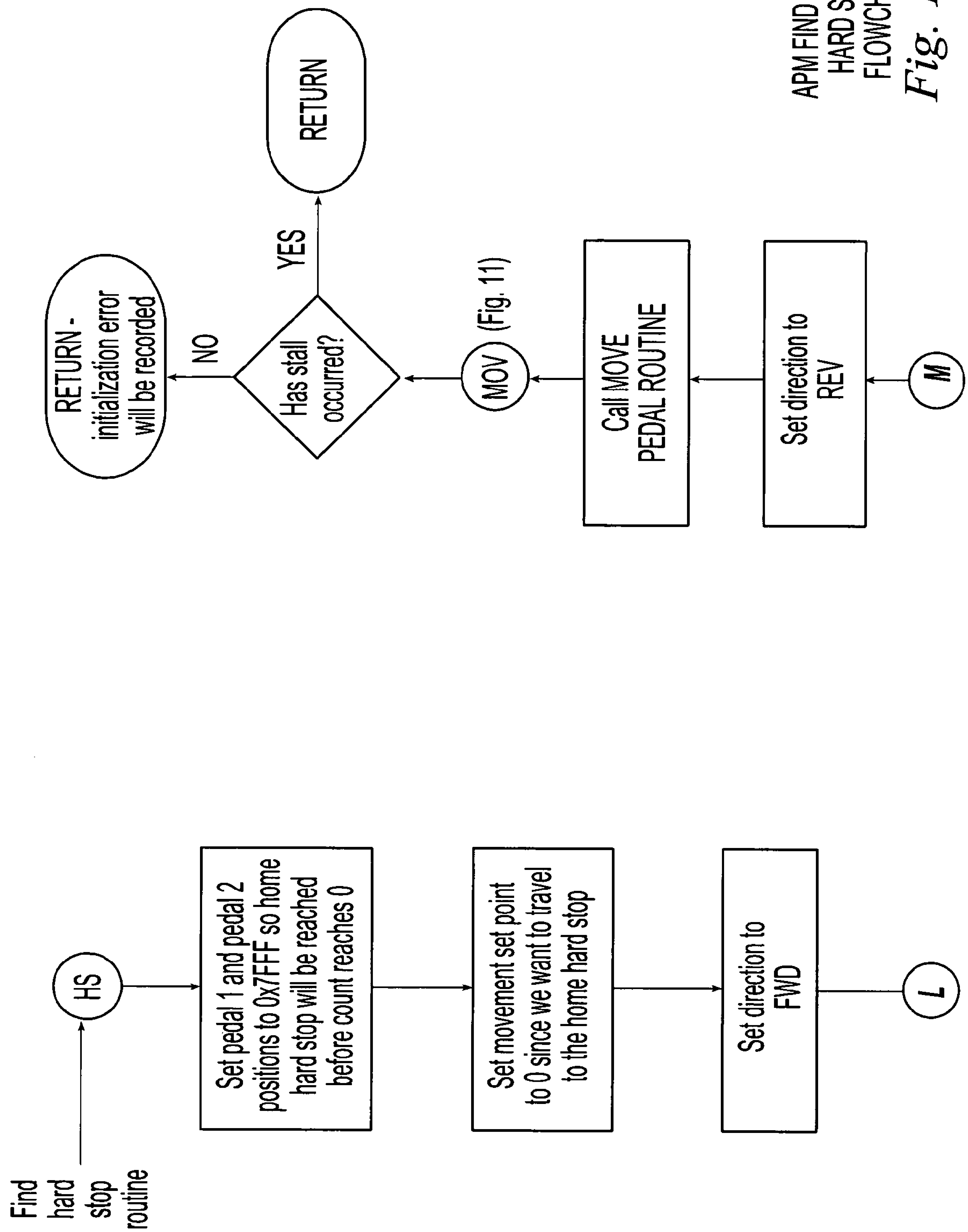
APM MEMORY BUTTON FLOWCHART

Fig. 9A



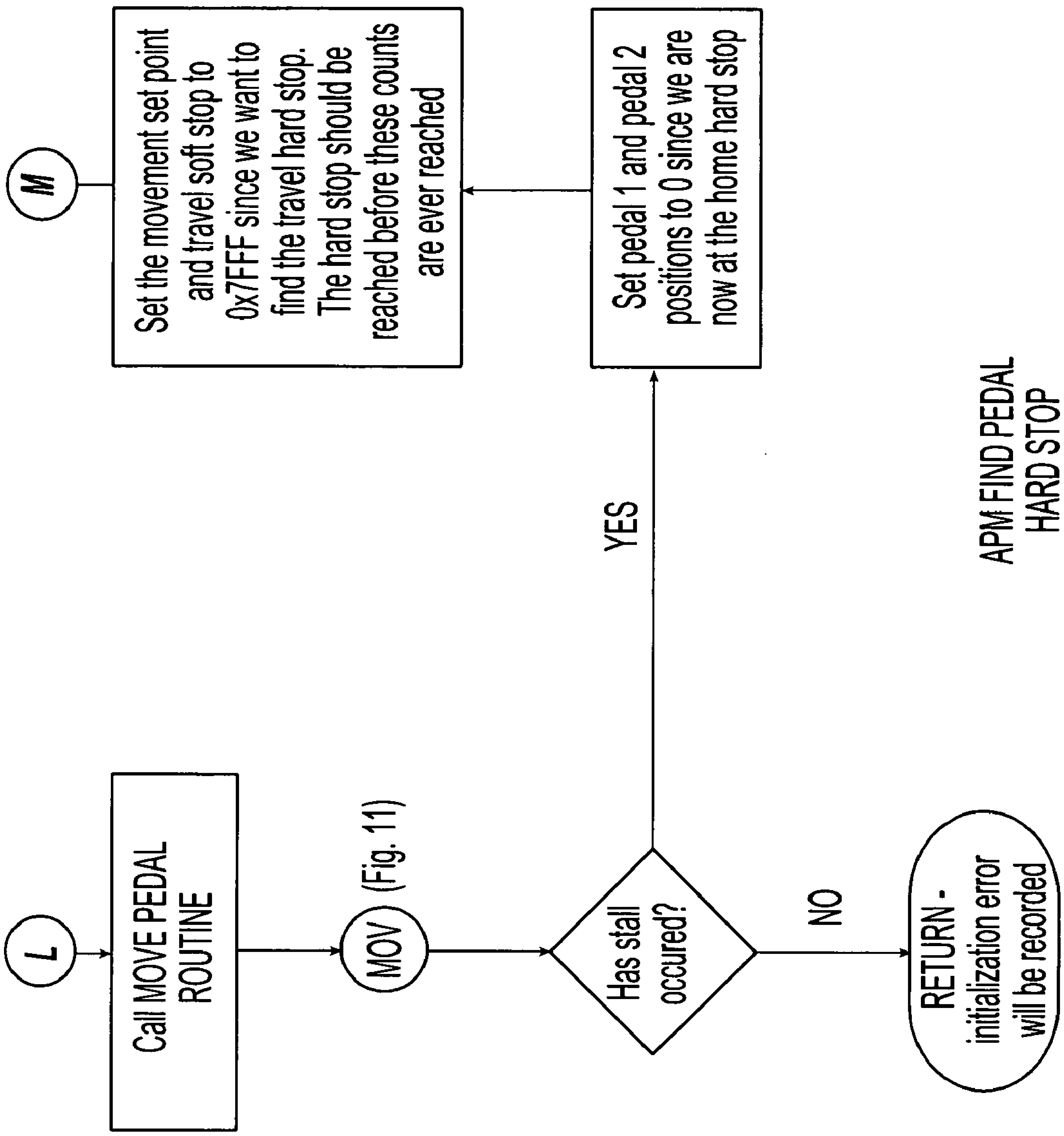
APM MEMORY BUTTON FLOWCHART

Fig. 9B



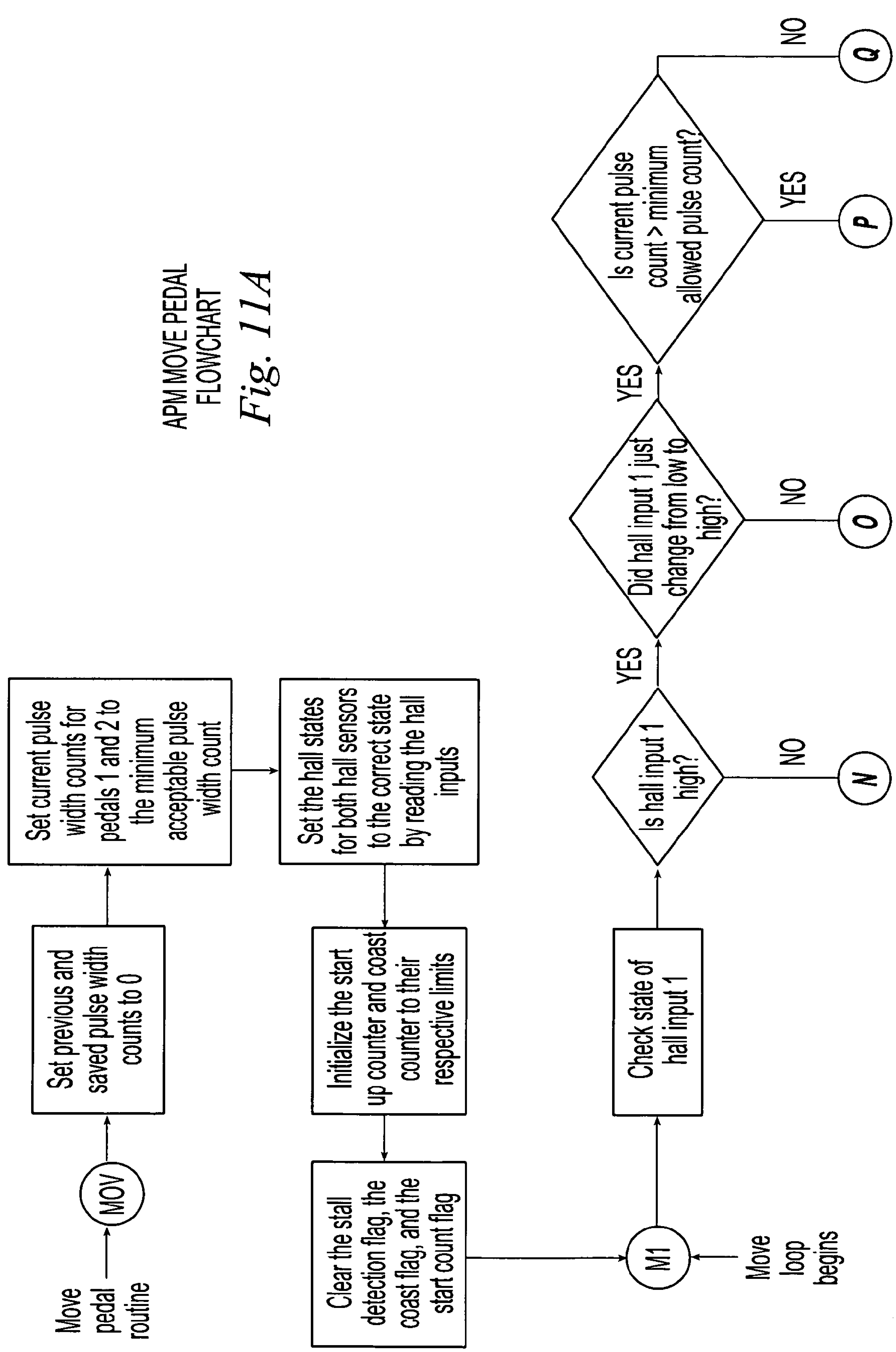
APM FIND PEDAL HARD STOP FLOWCHART

Fig. 10A



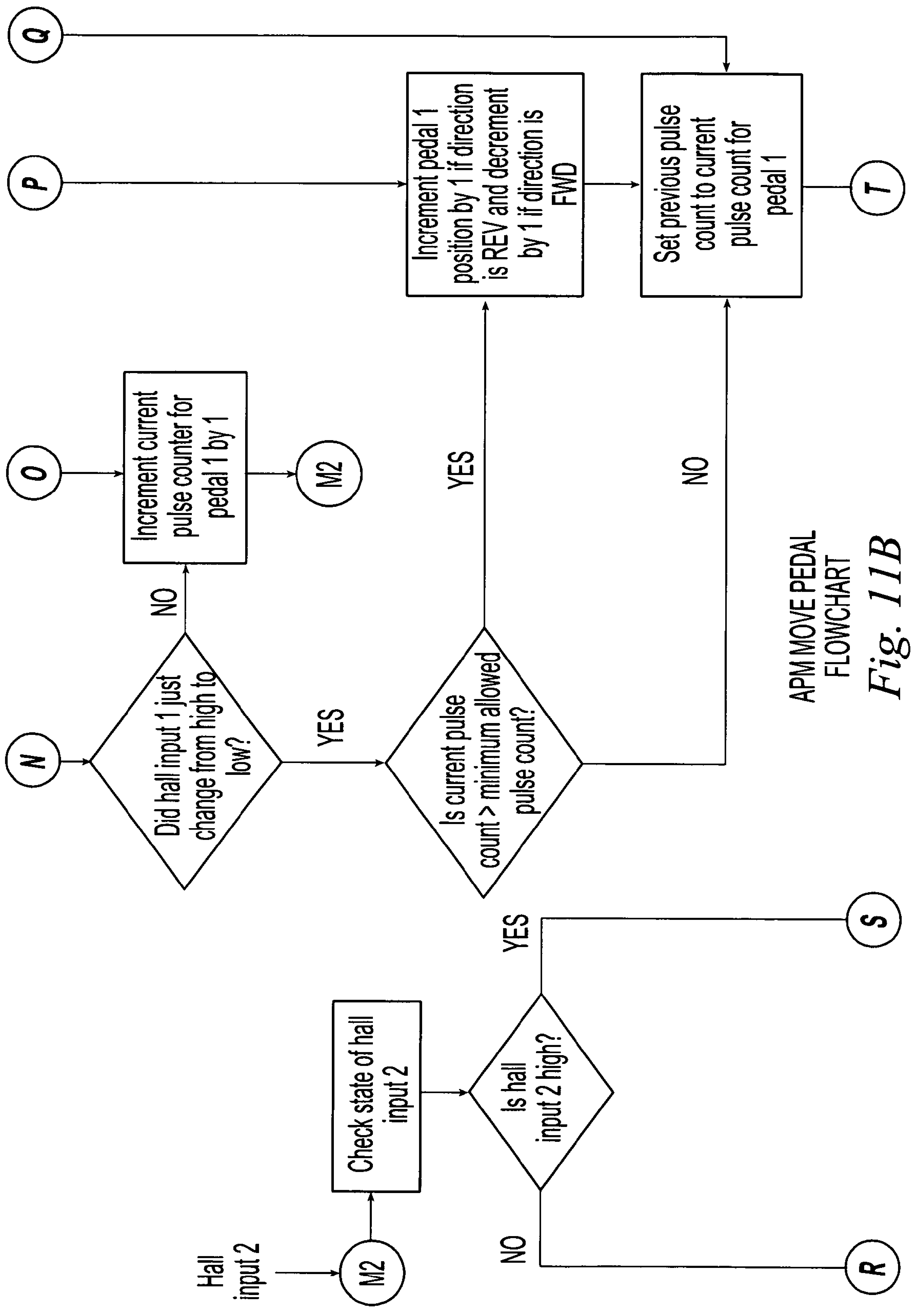
APM FIND PEDAL HARD STOP FLOWCHART

Fig. 10B



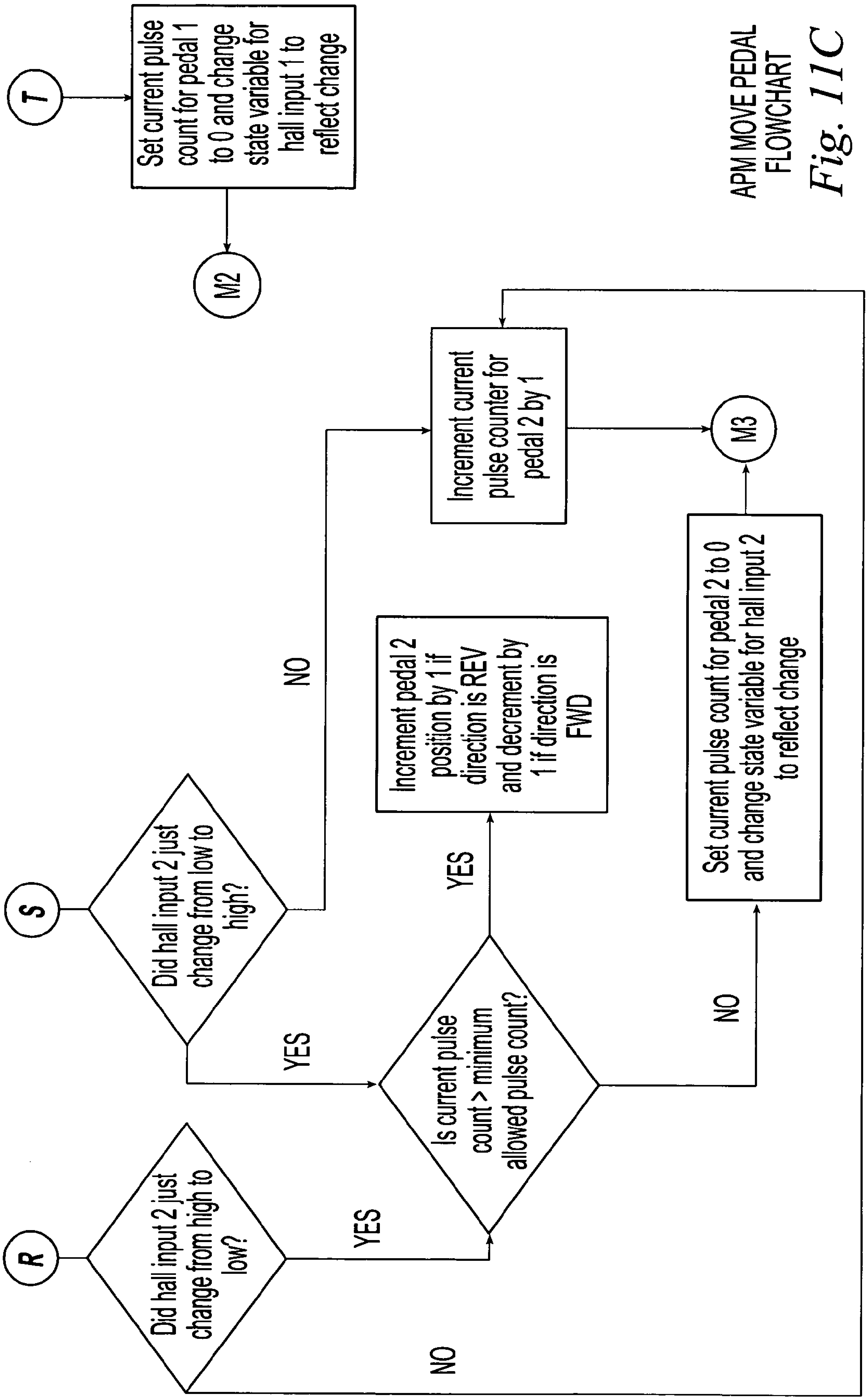
APM MOVE PEDAL FLOWCHART

Fig. 11A



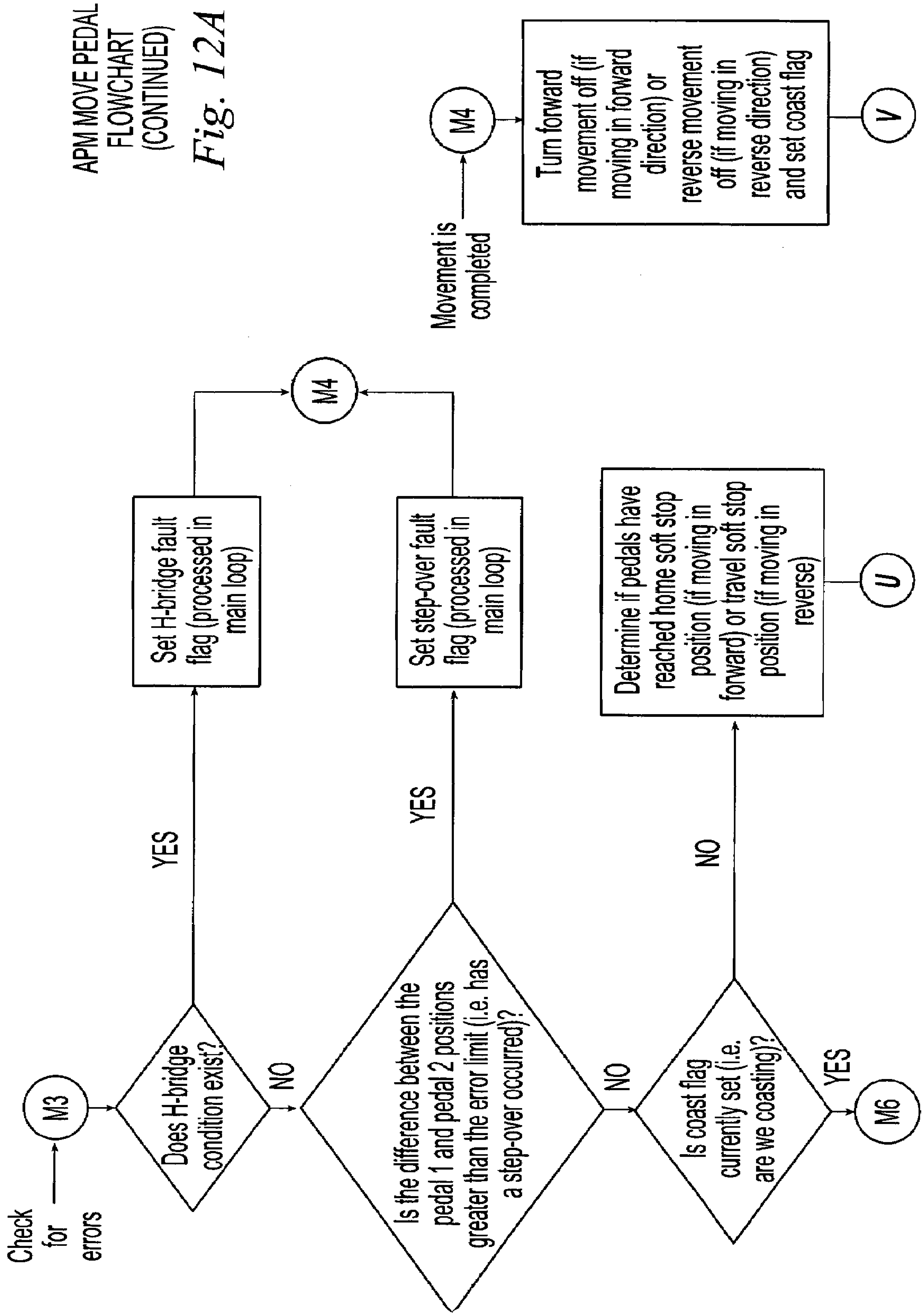
APM MOVE PEDAL FLOWCHART

Fig. 11B



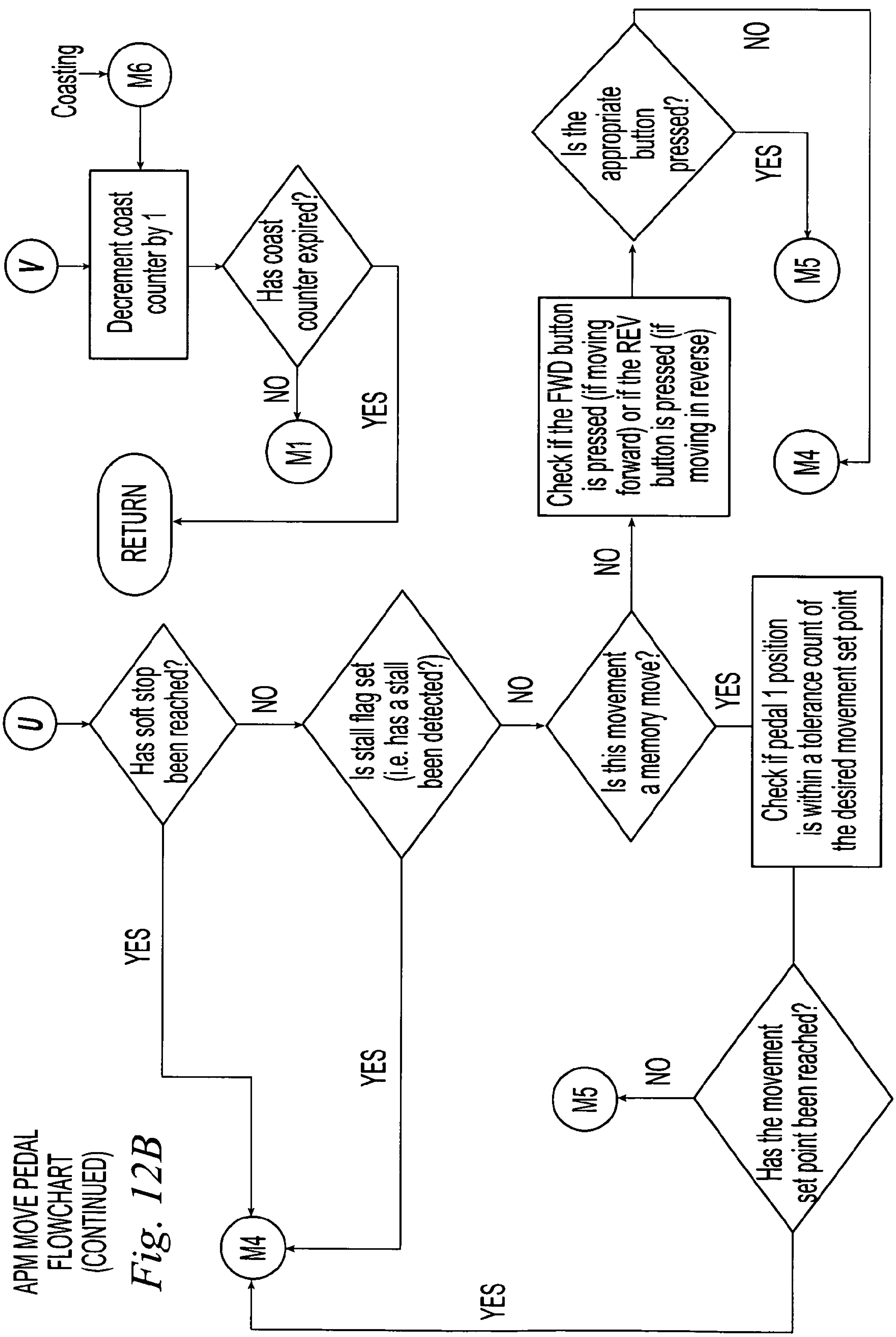
APM MOVE PEDAL FLOWCHART

Fig. 11C



APM MOVE PEDAL FLOWCHART (CONTINUED)

Fig. 12A

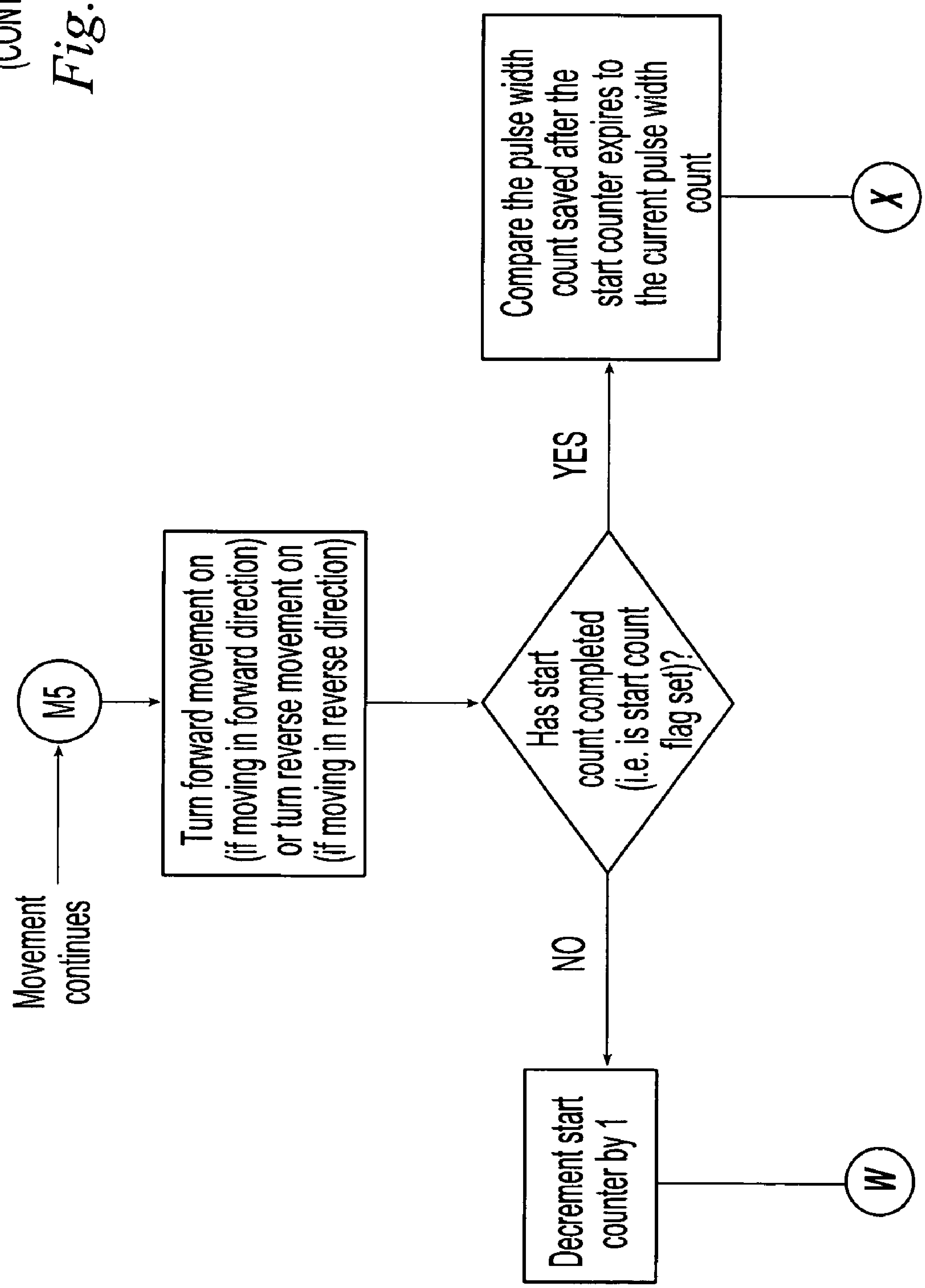


APM MOVE PEDAL FLOWCHART (CONTINUED)

Fig. 12B

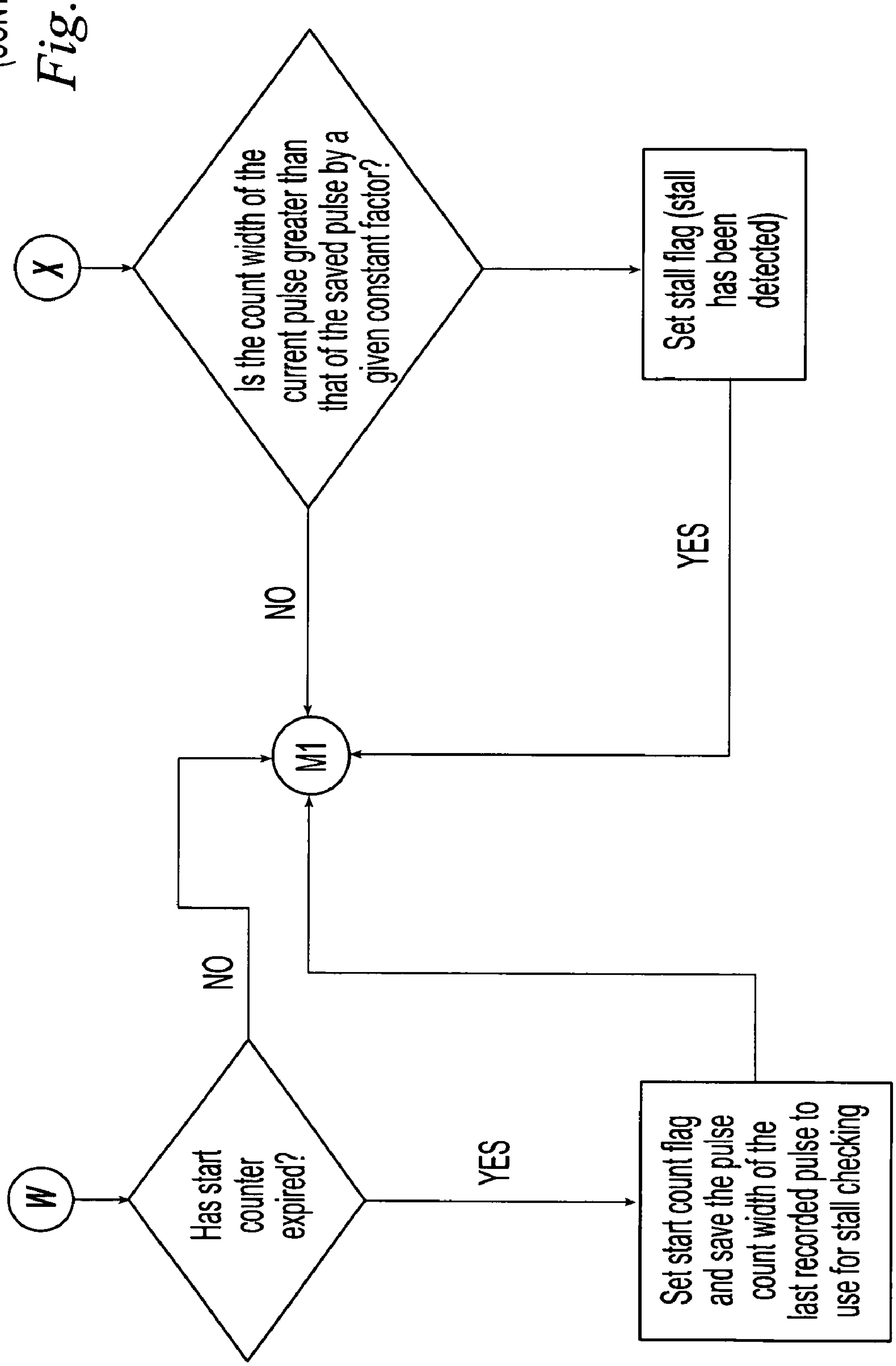
APM MOVE PEDAL
FLOWCHART
(CONTINUED)

Fig. 13A



APM MOVE PEDAL FLOWCHART (CONTINUED)

Fig. 13B



ADJUSTABLE PEDAL CONTROLLER WITH OBSTRUCTION DETECTION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part application of patent application Ser. No. 09/748,666 filed on Dec. 22, 2000 now U.S. Pat. No. 6,739,212, the disclosure of which is expressly incorporated herein in its entirety by reference.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

Not Applicable

REFERENCE TO MICROFICHE APPENDIX

Not Applicable

FIELD OF THE INVENTION

The present invention generally relates to improved adjustable pedal assemblies for motor vehicles and, more particularly, to control systems for adjusting control pedals to desired positions.

BACKGROUND OF THE INVENTION

Control pedals are typically provided in a motor vehicle, such as an automobile, which are foot operated by the driver. Separate control pedals are provided for operating brakes and an engine throttle. When the motor vehicle has a manual transmission, a third control pedal is provided for operating a transmission clutch. A front seat of the motor vehicle is typically mounted on tracks so that the seat is forwardly and rearwardly adjustable along the tracks to a plurality of positions so that the driver can adjust the front seat to the most advantageous position for working the control pedals.

This adjustment method of moving the front seat along the tracks generally fills the need to accommodate drivers of various size, but it raises several concerns. First, this adjustment method still may not accommodate all drivers due to very wide differences in anatomical dimensions of drivers. Second, the necessary position of the seat may be uncomfortable for some drivers. Therefore, it is desirable to have an additional or alternate adjustment method to accommodate drivers of various size.

Many proposals have been made to selectively adjust the position of the control pedals relative to the steering wheel and the front seat in addition to adjusting the front seat in order to accommodate drivers of various size. These adjustable control pedals can actuate either a cable which is connected to an engine throttle, for example, or an electronic throttle control (ETC) where an electric signal is sent to the engine throttle which is proportional to the positioning of the pedal. Such "drive-by-wire" ETC pedals were adapted from fly-by-wire" aircraft pedals, and the ETC can be, for example, either a dual slope potentiometer where the electric signal is proportional to rotation of the pedal, or a linear variable displacement transducer (LVDT) where the electric signal is proportional to linear displacement of the pedal or a carrier operatively connected to the pedal. See, for example, U.S. Pat. No. 5,056,742 to Sakurai showing adjustable pedals which control brakes and rudders of a motor vehicle such as an aircraft. A mounting frame or carrier is mounted in a base frame or support structure so that the carrier can be adjusted forward or rearward by operation of a screw device or drive assembly. Pedals are pivotally connected directly to the multi-part carrier for pivotal movement relative to the carrier and are moved to various adjusted positions with the forward/rearward movement of the carrier relative to the support structure. Transducers or generator means are mounted on the carrier and move with the carrier to the various adjusted positions. These transducers have outputs responsive to the pivotal movement of the pedals relative to the carrier which vary in magnitude in proportion to the extent of movement of the pedals relative to the carrier. It is readily apparent to those skilled in the art of adjustable control pedals that the pedals connected to the carrier can have many different forms depending on the requirements of the particular motor vehicle such as, for example, in automobiles the pedal is typically in the form of a pedal arm extending from a pivot connection to a lower end having a pad.

U.S. Pat. Nos. 5,632,183, 5,697,260, 5,722,302, 5,819,593, 5,937,707, and 5,964,125, the disclosures of which are expressly incorporated herein in their entirety by reference, each disclose an example of an adjustable control pedal assembly. This control pedal assembly includes a hollow guide tube, a rotatable screw shaft coaxially extending within the guide tube, a nut in threaded engagement with the screw shaft and slidable within the guide tube, and a control pedal rigidly connected to the nut. The control pedal is moved forward and rearward when an electric motor rotates the screw shaft to translate the nut along the screw shaft within the guide tube. While this control pedal assembly may adequately adjust the position of the control pedal to accommodate drivers of various size, this control pedal assembly is relatively complex and expensive to produce. The relatively high cost is particularly due to the quantity of high-precision machined parts such as, for example, the guide tube and due to the quantity of welded joints.

U.S. Pat. Nos. 3,643,525 and 3,643,524, the disclosures of which are expressly incorporated herein in their entirety by reference, each disclose an example of an adjustable control pedal assembly which is much less expensive to produce. This control pedal assembly includes an upper arm having a single horizontal slot, a rotatable screw shaft attached to the upper arm and extending along the slot, a nut in threaded engagement with the screw shaft and having a pin slidable within the slot, and a control pedal rigidly connected to the nut. The control pedal is moved forward and rearward when an electric motor rotates the screw shaft to translate the nut along the screw shaft. While this control pedal assembly may adequately adjust the position of the control pedal to accommodate drivers of various size and is relatively inexpensive to produce, this control pedal is relatively unstable and can have a relatively large amount of lash. That is, components of the control pedal are subject to vibration during regular operation of the motor vehicle causing the components to rub or strike together causing undesirable noise.

While these adjustable pedal systems may adequately adjust the position of control pedals, these systems often do not know the exact location of the control pedal and/or can cause injury or damage when the control pedals engage an obstruction. Accordingly, there is a need in the art for an adjustable pedal assembly which selectively adjusts the position of the control pedal to accommodate drivers of various size, is relatively simple and inexpensive to produce, is able reset in order to identify the exact position of the control pedal, is able to detect when an obstruction is engaged during movement of the control pedal, and/or is highly reliable to operate.

SUMMARY OF THE INVENTION

The present invention provides an adjustable control pedal for a motor vehicle which overcomes at least some of the above-noted problems of the related art. According to the present invention, an adjustable pedal assembly comprises, in combination, a carrier, a lower arm supported by the carrier and operatively connected to the carrier for selected movement relative to the carrier, and a drive assembly operatively connected to the lower arm to selectively move the lower arm relative to the carrier. The drive assembly comprises a drive screw connected to one of the lower arm and the carrier, a drive nut connected to the other of the lower arm and the carrier and cooperating with the drive screw such that the drive nut travels along the drive screw upon rotation of the drive screw, and an electric motor operatively connected to the drive screw to selectively rotate the drive screw. A sensor is provided which is adapted to detect motion information upon rotation of the drive screw. A controller receives the motion information and is adapted to activate the electric motor upon initialization of the controller to move the lower arm in a first direction until a first mechanical stop is engaged and establish a home stop position and to move the lower arm in the other direction opposite the first direction until a second mechanical stop is engaged and establish a travel stop position. The home stop position and the travel stop position represent the mechanical limits of travel for the lower arm.

According to another aspect of the present invention, an adjustable pedal assembly comprises, in combination, a carrier, a lower arm supported by the carrier and operatively connected to the carrier for selected movement relative to the carrier, and a drive assembly operatively connected to the lower arm to selectively move the lower arm relative to the carrier. The drive assembly comprises a drive screw connected to one of the lower arm and the carrier, a drive nut connected to the other of the lower arm and the carrier and cooperating with the drive screw such that the drive nut travels along the drive screw upon rotation of the drive screw, and an electric motor operatively connected to the drive screw to selectively rotate the drive screw. A sensor is provided which is adapted to detect motion information upon rotation of the drive screw. A controller is adapted to selectively activate the electric motor to move the lower arm, to receive the motion information, and to determine stall conditions of the lower arm based on the motion information during movement of the lower arm.

From the foregoing disclosure and the following more detailed description of various preferred embodiments it will be apparent to those skilled in the art that the present invention provides a significant advance in the technology and art of adjustable control pedal assemblies. Particularly significant in this regard is the potential the invention affords for providing a high quality, feature-rich, low cost assembly. Additional features and advantages of various preferred embodiments will be better understood in view of the detailed description provided below.

BRIEF DESCRIPTION OF THE DRAWINGS

These and further features of the present invention will be apparent with reference to the following description and drawings, wherein:

FIG. **1** is a perspective view of an adjustable pedal assembly according to a preferred embodiment of the present invention;

FIG. **1**A is a schematic view of the adjustable pedal assembly of FIG. **1**;

FIG. **1**B is a schematic end view of a hall-effect switch and ring magnet of FIG. **1**A;

FIG. **1**C is a graph showing output of the hall-effect sensor of FIG. **1**B over time;

FIG. **2** is a left side elevational view of a first adjustable control pedal of the adjustable control pedal assembly of FIG. **1**;

FIG. **3** is a rear elevational view of the first adjustable control pedal of FIG. **2**;

FIG. **4** is an exploded elevational view of the adjustable control pedal of FIGS. **2** and **3**;

FIG. **5** is an enlarged left perspective view of an upper portion of the adjustable control pedal of FIGS. **2** to **4**;

FIG. **6** is an enlarged right side perspective view of an upper portion of the adjustable control pedal of FIGS. **2** to **5**;

FIGS. **7**A to **7**C are a flowchart of a preferred initialization routine utilized by the controller of the adjustable pedal assembly of FIG. **1**;

FIGS. **8**A to **8**C are a flowchart of a preferred main program loop utilized by the controller of the adjustable pedal assembly of FIG. **1**;

FIGS. **9**A and **9**B are a flowchart of a preferred memory button routine utilized by the controller of the adjustable pedal assembly of FIG. **1**;

FIGS. **10**A and **10**B are a flowchart of a preferred find pedal hard stop routine utilized by the controller of the adjustable pedal assembly of FIG. **1**;

FIGS. **11**A to **11**C are a flowchart of a preferred move pedal routine utilized by the controller of the adjustable pedal assembly of FIG. **1**;

FIGS. **12**A and **12**B are a flowchart which is a continuation of the preferred move pedal routine of FIGS. **1**A to **11**C; and

FIGS. **13**A and **13**B are a flowchart which is a continuation of the preferred move pedal routine of FIGS. **11**A to **11**C and FIGS. **12**A and **12**B.

It should be understood that the appended drawings are not necessarily to scale, presenting a somewhat simplified representation of various preferred features illustrative of the basic principles of the invention. The specific design features of an adjustable control pedal as disclosed herein, including, for example, specific dimensions, orientations, and shapes of the pedal arms and the slots will be determined in part by the particular intended application and use environment. Certain features of the illustrated embodiments have been enlarged or distorted relative to others to facilitate visualization and clear understanding. In particular, thin features may be thickened, for example, for clarity or illustration. All references to direction and position, unless otherwise indicated, refer to the orientation of the control pedal assembly illustrated in the drawings. In general, up or upward refers to an upward direction in the plane of the paper in FIGS. **2** and **3** and down or downward refers to a downward direction in the plane of the paper in FIGS. **2** and **3**. Also in general, fore or forward refers to a direction toward the front of the motor vehicle, that is, to the left in the plane of the paper in FIG. **2** and aft or rearward refers to a direction toward the rear of the motor vehicle, that is, to the right in the plane of the paper in FIG. **2**.

DETAILED DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

It will be apparent to those skilled in the art, that is, to those who have knowledge or experience in this area of technology, that many uses and design variations are possible for the improved adjustable pedal assembly disclosed herein. The following detailed discussion of various alternative and preferred embodiments will illustrate the general principles of the invention with reference to an adjustable pedal assembly for use with a motor vehicle. Other embodiments suitable for other applications will be apparent to those skilled in the art given the benefit of this disclosure.

Referring now to the drawings, FIG. **1** shows an adjustable pedal assembly **10** for a motor vehicle, such as an automobile, according to a preferred embodiment of the present invention which has control pedals selectively adjustable to desired forward/rearward positions by an operator or driver of the motor vehicle. While the illustrated embodiments of the present invention are particularly adapted for use with an automobile, it is noted that the present invention can be utilized with any vehicle having at least one foot operated control pedal including trucks, buses, vans, recreational vehicles, earth moving equipment and the like, off road vehicles such as dune buggies and the like, air borne vehicles, and water borne vehicles.

As best shown in FIGS. **1** and 1A, the illustrated adjustable pedal assembly **10** includes first and second adjustable control pedals **12***a*, **12***b* and a control system **14** for selectively adjusting the position of the control pedals **12***a*, **12***b*. Typically, the control pedals **12***a*, **12***b* are adapted as brake and accelerator pedals respectively. While the illustrated adjustable pedal assembly **10** includes two control pedals **12***a*, **12***b*, it is noted that the adjustable pedal assembly **10** can have a single control pedal within the scope of the present invention such as, for example, a single control pedal adapted as a clutch, brake or accelerator pedal. It is also noted that the adjustable pedal assembly **10** can have more than two control pedals **12** within the scope of the present invention such as, for example, three control pedals adapted as clutch, brake and accelerator pedals. The control pedals **12***a*, **12***b* are selectively adjustable by the motor vehicle operator in a forward/rearward direction as described in more detail hereinafter. In multiple control pedal embodiments, the control pedals **10** are preferably adjusted together simultaneously to maintain desired relationships between the control pedals such as, for example, "step over", that is, the forward position of the accelerator pedal **12***b* relative to the brake pedal, **12***a* and "pedal angles", that is, the orientation of the contact surfaces of the pedal pads. It is noted however, that individual adjustment of a single control pedal **12***a*, **12***b* is within the scope of the present invention.

While only the first control pedal **12***a*, which is adapted as a brake pedal, is described in detail hereinbelow, the second control pedal **12***b*, which is adapted as an accelerator pedal, is generally the same except as noted herein and as apparent to those skilled in the art given the benefit of this disclosure. For a detailed description of other suitable adjustable control pedals **12***a*, **12***b* adapted as both brake and accelerator pedals, see, for example, U.S. Pat. No. 564,355, the disclosure of which is expressly incorporated herein in its entirety by reference.

As best shown in FIGS. **2**–**6**, the first control pedal **12***a* includes an upper pedal arm or carrier **16** having first and second plates or members **18**, **20**, a lower pedal arm **22** supported by the upper pedal arm **16** and carrying a pad or pedal **24** for engagement by the foot of the motor vehicle operator, and a drive assembly **26** for moving of the lower pedal arm **22** relative to the upper pedal arm **16** to adjust the forward/rearward position of the pedal **24**. The upper pedal arm **16** is sized and shaped for pivotal attachment to a mounting bracket **28**. The mounting bracket **28** is adapted to rigidly attach the adjustable control pedal **12** to a firewall or other rigid structure of the motor vehicle in a known manner. The upper pedal arm **16** is adapted for pivotal attachment to the mounting bracket **28**. The illustrated first and second members **18**, **20** of the upper pedal arm **16** each have an opening **30** formed for cooperation with the mounting bracket **28** and an axle or pivot pin **32**. With the pivot pin **32** extending through the mounting bracket **28** and the openings **30** of the first and second members **18**, **20**, the upper pedal arm **16** is pivotable relative to the fixed mounting bracket **28** about a horizontally and laterally extending pivot axis **34** formed by the central axis of the pivot pin **32**. A spacer **36** is preferably provided about the pivot pin **32** between the first and second members **18**, **20** to maintain a desired distance between the first and second members **18**, **20**. The illustrated first and second members **18**, **20** of the upper pedal arm **16** are substantially identical and are rigidly connected together to pivot together about the pivot pin **32** in unison.

The lower portion of the first and second members **18**, **20** is adapted for supporting the lower pedal arm **22** and for selected fore and aft movement of the lower pedal arm **22** relative to the first and second members **18**, **20** along the lower portion as described in more detail hereinafter. The illustrated lower portion has a pair of vertically spaced apart elongate openings or slots **38**, **40** formed therein which generally extend in a forward/rearward direction along the length of the lower portion. The illustrated slots **38**, **40** are each substantially straight. Preferably, the drive or lower slot **40** is offset rearward of the guide or upper slot **38** but overlapping the upper slot **38**. The lower portion is substantially planar or flat at least in the areas adjacent the slots **38**, **40** and the slots **38**, **40** are open laterally through the entire thickness of the first and second members **18**, **20**. The slots **38**, **40** are sized and shaped for cooperation with the lower pedal arm **22** for substantially linear forward/rearward movement of the pedal **24** relative the upper pedal arm **16** over a desired adjustment range, such as about three inches, as described in more detail hereinbelow. It is noted that the separate upper and lower slots **38**, **40** can alternatively be separate portions of a single slot such as a "C-shaped", "S-shaped", or other nonlinear slot.

The upper pedal arm **16** is operatively connected to a control device such as a clutch, brake or throttle such that pivotal movement of the upper pedal arm **16** about the pivot axis **34** operates the control device in a desired manner. The upper pedal arm **16** can be connected to the control device by, for example, a push-pull or Bowden cable for mechanical actuation or by a sensor or electrical wire or cable for electronic actuation. The illustrated upper pedal arm **16** is provided with a booster pin **42** for connection to the control device by a mechanical actuator. The illustrated upper pedal arm **16** is also provided with a switch pin **44** for connection to a switch for indicator lights such as brake lights so that the indicator lights indicate actuation of the pedal, that is, pivotal movement about the pivot axis **34**, of the control pedal **12** by the operator.

The upper and lower pedal arms **16**, **22** are preferably formed of a suitable metal such as steel but one or both can alternatively be formed of other suitable materials such as, for example, plastics like NYLON, aluminum, or magnesium. The illustrated lower pedal arm **22** is formed of an elongate plate oriented in a vertical plane substantially parallel to planes of the first and second members **18**, **20**. The upper end of the lower pedal arm **22** is adapted for movement relative to the upper pedal arm **16** between first and second members **18**, **20** and along the upper and lower slots **38**, **40**. The upper end of the lower pedal arm **22** is provided with upper and lower guide pins or blocks **48**, **50** laterally and horizontally extending there from to cooperate with the slots **38**, **40** of the first and second members **18**, **20** to form four sliding pin-and-slot connections for linearly moving the lower pedal arm **22** relative to the upper pedal arm **16**. The lower end of the lower pedal arm **22** is sized and shaped to carry the rearward-facing pedal **24**. The pedal **24** is adapted for depression by the driver of the motor vehicle to pivot the control pedal **12** about the pivot axis **34** to obtain a desired control input to the motor vehicle through the movement of the booster pin **42**. It is readily apparent to those skilled in the art that the pedal arm **22** can be comprised of plastic or metal, and that the pedal arm **22** can be of unitary construction with the pedal or pad **24** or, alternatively, can have a pad support at its lower end to receive the pedal or pad **24** so that the pad **24** can be comprised of rubber or other suitable material for foot comfort.

Bushings **52** preferably encircle end portions of the guide pins **48**, **50** and extend within the slots **38**, **40**. The bushings **52** are sized and shaped to closely conform with the guide pins **48**, **50**, particularly at the engagement surfaces contacting the edges of the slots **38**, **40**. The guide pins **48**, **50** and the bushings **52** are sized and shaped so that there is very little or no vertical movement or "play" for the guide pins **48**, **50** within the slots **38**, **48**. Flanges of the bushings **52** are preferably sized to extend between the lower pedal arm **22** and the first and second members **18**, **20** so that there is very little or no lateral movement or "play" for the lower pedal arm **22** between the first and second members **18**, **20**. The bushings **52** are preferably formed of a suitable plastic or polymer material but can alternatively be any other type of suitable wear resistant and/or low friction material.

The drive assembly **26** includes a screw shaft or drive screw **54**, a drive screw attachment or housing **56** for securing the drive screw **54** to the upper pedal arm **16**, a drive nut **58** adapted for movement along the drive screw **54** in response to rotation of the drive screw **54**, an electric motor **60** for rotating the drive screw **54**, and a drive cable **62** for operatively connecting the electric motor **60** to the drive screw **54** and transmitting rotational motion and torque thereto.

The drive screw **54** is an elongate shaft having a threaded portion adapted for cooperation with the drive nut **58**. The drive screw **54** is preferably formed of metal such as, for example, steel but can be alternately formed of a plastic resin such as, for example, NYLON. The forward end of the drive screw **54** is journaled by the drive screw housing **56** for rotation of the drive screw **54** about its longitudinal axis by the electric motor **60**. The drive screw **54** rearwardly extends from the drive screw housing **56** generally parallel to and adjacent the lower slots **38** in the first and second members **18**, **20** in a cantilevered fashion. Mounted in this manner, the drive screw **54** is generally horizontal. The illustrated drive screw **54** is provided with a bushing **64** for connection to the housing **56** to form a relatively fixed rotating joint. The drive screw **56** can alternatively be connected to the drive screw housing **56** with a self-aligning or freely pivoting rotating joint, that is, a joint which freely permits pivoting of the drive screw **54** relative to the drive screw housing **56** and the first and second members **18**, **20** about at least axes perpendicular to the drive screw rotational axis **66**. The self-aligning joint automatically corrects misalignment of the drive screw **54** and/or the drive nut **58**. The self-aligning joint also allows the lower slot **40** to be nonlinear when desired. The self aligning joint can be, for example, a ball/socket type joint.

The drive screw housing **56** is sized and shaped for supporting the forward end of the drive screw **54** and attaching the drive screw **54** to the first and second members **18**, **20**. The drive screw housing **56** is preferably molded of a suitable plastic material such as, for example, NYLON but can alternatively be formed of metal such as steel. The illustrated drive-screw housing **56** is secured to the upper pedal arm **16** with a snap-fit connection. It is noted, however, that the drive screw housing **56** can be secured to the upper pedal arm **16** in other suitable manners such as, for example, welding, staking, or mechanical fasteners.

The drive nut **58** is adapted for axial movement along the drive screw **54** in response to rotation of the drive screw **54**. The drive nut **58** is preferably molded of a suitable plastic material such as, for example, NYLON but can alternatively be formed of metal such as, for example steel. The illustrated drive nut **58** is rigidly secured to the lower guide pin **50**. The lower guide pin **50** can be alternatively connected to the drive nut **58** with a self-aligning or freely pivoting joint, that is, a joint which freely permits pivoting of the drive nut **58** relative to the lower guide pin **50** about at least axes perpendicular to the rotational axis **66** of the drive screw **54**. The self-aligning joint automatically corrects misalignment of the drive nut **58** and/or the drive screw **54**. The self aligning joint can be, for example, a ball/socket type joint.

The electric motor **60** can be of any suitable type and can be secured to the firewall or other suitable location such as, for example, the mounting bracket **28**. The drive cable **62** is preferably a flexible push-pull-type or Bowden cable and connects the output shaft of the electric motor **60** and the forward end of the drive screw **54** so that rotation of the electric motor **60** rotates the drive screw **54**. It is noted that the drive screw **54** and the electric motor **60** can be alternatively connected with a rigid connection. It is noted that suitable gearing **68** is provided between the electric motor **60** and the drive screw **54** as necessary depending on the requirements of the adjustable pedal assembly **10**. It is also noted that the fixed portion or sheath of the drive cable **62** is rigidly secured to the forward end of the drive screw housing **56** and a rotating portion or core of the drive cable **62** is operatively connected to the forward end of the drive screw **54** to rotate the drive screw **54** therewith. See U.S. patent application Ser. No. 09/492,238, the disclosure of which is expressly incorporated herein in its entirety by reference, for a more detailed description of a suitable drive screw, housing, and/or cable support. Also see U.S. patent application Ser. No. 09/642,975, the disclosure of which is expressly incorporated herein in its entirety by reference, for a more detailed description of the control pedal **12**.

As best shown in FIG. **1**A, the control system **14** preferably includes a central processing unit (CPU) or controller **70** for operating the electric motor **60**, an operator interface **72** for exchanging information between the driver and the controller **70**, and at least one sensor **74** for detecting motion of the control pedals **12***a*, **12***b* and providing such motion information to the controller **70**. The control system **14** forms a control loop wherein the controller **70** selectively activates and deactivates the electric motor **60**. When activated, the electric motor **60** rotates the drive screws **54** through the drive cables **62**. It is noted that while the drive screws **54** of the illustrated embodiment are connected to the electric motor **60** in parallel, they can alternatively be connected to the electric motor **60** in series. The sensor or sensors **74** detect movement of the control pedals **12***a*, **12***b* and send(s) signals to the controller **70** which enables the controller **70** to deactivate the electric motor **60** when movement to a desired position has been obtained.

The controller **70** includes processing means and memory means which are adapted to control operation of the adjustable pedal assembly **10** as described in detail herein. The controller **70** is preferably in communication with a motor vehicle control unit **76** through a local bus **78** of the motor vehicle or a direct connection so that motor vehicle information, such as ignition switch information, can be supplied to or examined by the controller **70** and status of the adjustable pedal assembly **10** can be supplied to or examined by the motor vehicle control unit **76**. It is noted that while illustrated control system **14** utilizes a dedicated controller **70**, the controller can alternatively be the motor vehicle control unit **76** or a controller of another system of the motor vehicle such as, for example, a keyless entry system or a powered seat system.

The illustrated operator interface **72** includes a forward button or switch **80**, a reverse or rearward button or switch **82**, an indicator device **84**, and first and second memory buttons or switches **86**, **88**. When activated, the forward switch **80** sends control signals to the controller **70** to move the control pedals **12***a*, **12***b* in a forward direction. When activated, the reverse switch **82** sends control signals to the controller **70** to move the control pedals **12***a*, **12***b* in a rearward direction. The illustrated forward and rearward switches **80**, **82** are a single rocker-type switch but can be other types of suitable switches such as, for example, push-button switches or toggle switches. The illustrated indicator device **84** is an indicator or status light such as an LED which is selectively illuminated to convey information to the operator. It is noted that the indicator device **84** can alternatively be other suitable types of devices which can convey information such as, for example, an LED or LCD display. When activated, the memory switches **86**, **88** send control signals to the controller **70** to move the control pedals **12***a*, **12***b* to preferred locations previously saved in memory of the controller **70**. Preferably, when activated and held for a predetermined period of time, such as about two seconds, the controller **70** saves the current position in memory so that subsequent actuation of that memory switch **86**, **88** will send a control signal to the controller **70** to move the control pedals **12***a*, **12***b* to the current location. Preferably, the indicator device **84** acknowledges the saving of the current position by for example, blinking the indicator light for a predetermined period of time. The illustrated memory switches **86**, **88** are a single push-button switches but can be other types of suitable switches such as, for example, toggle switches. It is noted that the operator interface **72** can also include other control switches when desired such as, for example, a lock out button or switch which when activated sends control signals to deactivate the system and prevent movement of the control pedals **12***a*, **12***b* and/or an override button or switch which when activated permits the control pedals **12***a*, **12***b* to be moved by the driver in a desired manner regardless of existing conditions.

The illustrated embodiment provides each control pedal **12***a*, **12***b* with a sensor **74** to detect movement of the control pedals **12***a*, **12***b* and send signals relating to such movement information to the controller **70**. Alternatively, a single sensor **74** or more than two sensors **74** can be utilized. The illustrated sensors **74** are located adjacent the drive screws **54** and are adapted provide movement information, in the form of distance and speed information, to the controller **70**. The sensors **74** are preferably hall-effect switches mounted adjacent ring magnets **90**. As best shown in FIG. **1**B, each ring magnet **90** comprises a predetermined number of north and south poles such as, for example, a total of about 24 to 34 north and south poles. It is noted, however, that a ring magnet with any number of poles can be used. The ring magnet **90** is mounted for rotation with the drive screw **54** so that the predetermined number of magnet poles pass the sensor **74** each revolution of the drive screw **54**. During rotation of the drive screw **54**, the sensor **74** provides a square wave pulse stream to the controller **70**. As best shown in FIG. **1**C, the width of each pulse indicates the time one type of magnet pole was adjacent the sensor **74** and the width between pulses indicates the time the other type of magnet pole was adjacent the sensor. Therefore, width of the pulses and width between pulses proportionally decreases as rotational velocity of the drive screw **54** increases. Speed can be determined by pulse width, width between pulses, or preferably by both pulse width and width between pulses. The distance the drive nut **58**, and thus the lower pedal arm **22**, travels with each rotation of the drive screw **54** is preprogrammed in the controller **70**. Therefore, the controller **70** can determine the location, speed, acceleration, and the like of the lower pedal arms **22** from the movement information received from the sensors **74**. This motion information is used by the controller **70** in many ways as described in detail hereinbelow.

It is noted that other suitable sensors can be alternatively utilized such as, for example, a potentiometer. The sensors **74** can alternatively be position sensors such as, for example, a linear hall-effect sensor and/or a linear potentiometer. The sensors **74** can also alternatively be a current shunt on the electric motor **60** providing motor commutator pulses to detect position or motor current. The sensors **74** can also be a current sensor mounted in a manner that allows the controller **70** to monitor the electric current delivered to the motor **60** and/or determine the instantaneous power supplied by the motor **60**. Therefore, it is noted that the sensors **74** can alternatively have other locations such as, for example, between the upper and lower pedal arms **16**, **22** and/or at the electric motor **60**. Other motion information sensors **74** and locations for the sensors **74** will be apparent to those skilled in the art given the benefit of this disclosure.

The motion information from the sensors **74** can be utilized to automatically stop the control pedals **12***a*, **12***b* at ends of travel along the drive screw **54**. The controller **70** is preferably adapted to stop the motor **60** when motion information indicates that the drive nut **58** has reached a predetermined end of travel along the drive screw **54** prior to engaging a "hard" or mechanical stop or abutment. The position of the "soft" or electronic stop points relative to the hard stop points at the end of travel are preferably preprogrammed or determined by the controller **70**. When the controller **70** determines that the control pedals **12***a*, **12***b* have reached the soft or electronic stop points, the controller **70** stops the motor **60** and thus movement of the drive nuts **58** along the drive screws **54**. Fore-aft movement of the lower pedal arms **16**, therefore, is electronically stopped without engaging mechanical stops and resulting stress on the motor **60** and mechanical components. When a hard stop is engaged, the motor **60** stalls and current increases which may cause overheating of the motor **60** and a resulting shortened life of the motor **60**. It is noted, however, that the adjustable pedal assembly **10** is preferably provided with hard stops for limiting travel of the drive nuts **58** beyond the soft stops for use in initializing or resetting the system **14** an use in the event of a failure of the soft stops. In the illustrated embodiment, the hard stops include the ends of the upper and lower slot **38**, **40** which form abutments which are engaged by the upper and lower guide pins **48**, **50** at the end of travel along the slots **38**, **40** to limit fore-aft movement of the lower arms **16** and axial movement of the drive nuts **58**.

The motion information from the sensors **74** can be utilized by the controller **70** to move the control pedals **12***a*, **12***b* to desired positions. Because each pulse of the sensor output indicates a predetermined distance traveled, the total number of pulses indicates the total distance traveled. Therefore, by setting a home position at zero pulses, every other position along the travel length can be defined by a number of pulses from the home position. The current position therefore can be identified by the controller **70** which keeps track of the cumulative effect of all of the pulses which have occurred since traveling from the home position. In the illustrated embodiment, the home or forward soft stop is set as zero pulses and the travel or rearward soft stop is set as the total number of pulses from the home soft stop. In this manner, the current position can be stored by storing the number of pulses that the current position is away from the home position.

The motion information from the sensors **74** can be utilized to detect an obstruction, or near obstruction, in the path of at least one of the control pedals **12***a*, **12***b* such as, for example, the operator's foot. A potential "pinch" situation is detected if signals from the sensors **74** to the controller **70** indicate that there is a stall condition, or near stall condition, by change in speed, acceleration, motor current, motor power, or the like, which indicates that an obstruction has been engaged, or is about to be engaged, by at least one of the control pedals **12***a*, **12***b*. If the sensors **74** detect a stall or obstruction, the controller **70** automatically stops the motor **60** and/or reverses direction of the movement for a predetermined distance or time or to the previous position to prevent injury to a person or damage to an object or the adjustable pedal assembly **10**. If the sensors **74** indicate a second obstruction upon reversing direction, the controller **70** places the system in fault mode and stops the motor **60** and/or again reverses direction of movement for a predetermined distance or time such as, for example, a percentage of the distance or time traveled since the first obstruction. For example, the assembly can be moved to a position approximately halfway between the first and second obstructions upon indication of the second obstruction. Preferably the indicator device **84** identifies that the system **14** is in fault mode such as, for example, by blinking the indicator light.

Because each pulse width is a function of time (the width is the time to travel a predetermined distance), the pulse widths or velocity information can be utilized to detect a stalled or obstruction condition. In the illustrated embodiment, after a predetermined start-up period which permits the system to reach full speed, such as about 6 to about 8 pulses, a time or pulse width is stored indicating a full speed pulse. The full speed pulse is determined each motion cycle to reduce the effect of long term degradations. During movement, each pulse width is compared to the stored full speed pulse width to determine if a stalled condition is beginning to take place. Preferably, an averaging algorithm is utilized wherein each pulse width (or some derivative of each pulse width) is compared to the sum of the stored full speed pulse width and a constant value. The constant value can be a fixed percentage, such as 50%, of the saved full speed pulse width. The fixed percentage is dependant on variables of the mechanical system and can be from about 10% to about 300%. Accordingly, each system must be tested to determine the optimum fixed percentage. If a measured pulse width is greater than the sum of the stored full speed pulse width and the constant value, there is an indication of a stall condition arising. Typically, more than one pulse width should indicate a stall condition arising before acting on the stalled condition depending on the desired sensitivity of the system **14**.

It should be noted that the control system can be adapted to detect that an obstruction condition is about to take place, or alternatively has occurred, utilizing motion information in the form of velocity information, acceleration information, motor current information, motor power information, or any combination thereof.

Velocity Based Detection As discussed above, for velocity based detection, one or more sensors **74** are suitably mounted on the pedal assembly **10** in a manner that allows the controller **70** to monitor the sensor(s) **74** to determine the velocity and position of the control pedals **12***a*, **12***b*. The controller **70** selectively powers the electric motor **60** to move the control pedals **12***a*, **12***b* in a fore or aft direction. After applying power to the motor **60**, the controller **70** waits a predetermined period of time to allow the motor **60** to reach its normal operating velocity. Alternatively, the controller **70** monitors the sensor(s) **74** and determines, based on predetermined criteria, when the normal operating velocity has been obtained. The normal operating velocity will change as environmental conditions change and as the system wears over time. The controller **70** then stores/records the this velocity value. If the initial recorded velocity value is less than some predetermined or pre-calculated value, the controller **70** stops the electric motor **60**. Alternatively, the controller **70** can stop the electric motor **60** and reapply power to the motor **60** so that the control pedals **12***a*, **12***b* move in the opposite direction for some predetermined time or distance. If the initial velocity value is above the minimum predetermined threshold, the controller **70** continues to calculate pedal velocity, and each time compares it to the original stored value, as the control pedals **12***a*, **12***b* move. If the current speed is ever lower than the original speed by some predetermined or pre-calculated threshold, the controller **70** stops the electric motor **60**. Alternatively, the controller **70** can stop the electric motor **60** and reapply power to the motor **60** so that the pedals move in the opposite direction for some predetermined time or distance. If a second obstruction is encountered upon reversing direction, the controller **70** places the system in fault mode and stops the motor **60** and/or again reverses direction of movement for a predetermined distance or time such as, for example, a percentage of the distance or time traveled since the first obstruction.

Acceleration Based Detection For acceleration (change in velocity) based detection, one or more sensors **74** are suitably mounted on the pedal assembly **10** in a manner that allows the controller **70** to monitor the sensor(s) **74** to determine the velocity, acceleration and position of the control pedals **12***a*, **12***b*. The controller **70** selectively powers the electric motor **60** to move the control pedals **12***a*, **12***b* in a fore or aft direction. After applying power to the motor **60**, the controller **70** waits a predetermined period of time to allow the motor **60** to reach its normal operating velocity. Alternatively, the controller **70** monitors the sensor(s) **74** and determines, based on predetermined criteria, when the normal operating velocity has been obtained. The normal operating velocity will change as environmental conditions change and as the system wears over time. The controller **70** then stores/records the this velocity value. If the initial recorded velocity value is less than some predetermined or pre-calculated value, the controller **70** stops the electric motor **60**. Alternatively, the controller **70** can stop the electric motor **60** and reapply power to the motor **60** so that the control pedals **12***a*, **12***b* move in the opposite direction for some predetermined time or distance. If the initial velocity value is above the minimum predetermined threshold, the controller **70** continues to periodically measure and record pedal velocity, and each time compares it to the previously recorded value, as the control pedals **12***a*, **12***b* move. If the velocity ever decreases by some predetermined or pre-calculated threshold, the controller **70** stops the electric motor **60**. Alternatively, the controller **70** can stop the electric motor **60** and reapply power to the motor **60** so that the pedals move in the opposite direction for some predetermined time or distance. If a second obstruction is encountered upon reversing direction, the controller **70** places the system in fault mode and stops the motor **60** and/or again reverses direction of movement for a predetermined distance or time such as, for example, a percentage of the distance or time traveled since the first obstruction.

Motor Current Based Detection For motor current based detection, one or more current sensors **74** are suitably mounted on the pedal assembly **10** in a manner that allows the controller **70** to monitor the electric current delivered to the electric motor **60** used to move the control pedals **12***a*, **12***b*. The controller **70** selectively powers the electric motor **60** to move the control pedals **12***a*, **12***b* in a fore or aft direction. After applying power to the motor **60**, the controller **70** waits a predetermined period of time to allow the motor **60** to reach its normal operating current. Alternatively, the controller **70** monitors the sensor(s) **74** and determines, based on predetermined criteria, when the normal operating current has been obtained. The normal operating current will change as environmental conditions change and as the system wears over time. The controller **70** then stores/records the this current value. If the initial recorded current value is more than some predetermined or pre-calculated value, the controller **70** stops the electric motor **60**. Alternatively, the controller **70** can stop the electric motor **60** and reapply power to the motor **60** so that the control pedals **12***a*, **12***b* move in the opposite direction for some predetermined time or distance.

If the initial current value is below the maximum predetermined threshold, the controller **70** continues to monitor the motor current, and each time compares it to the original stored value, as the control pedals **12***a*, **12***b* move. If the motor current is ever higher than the original motor current by some predetermined or pre-calculated threshold, the controller **70** stops the electric motor **60**. Alternatively, the controller **70** can stop the electric motor **60** and reapply power to the motor **60** so that the pedals move in the opposite direction for some predetermined time or distance. Alternatively, if the motor current value is below the maximum predetermined threshold, the controller **70** continues to measure and record motor current, each time comparing the current value to the previously recorded value. If the current increases by more than a predetermined or pre-calculated threshold, the controller **70** stops the electric motor **60**. Alternatively, the controller **70** can stop the electric motor **60** and reapply power to the motor **60** so that the pedals move in the opposite direction for some predetermined time or distance. If a second obstruction is encountered upon reversing direction, the controller **70** places the system in fault mode and stops the motor **60** and/or again reverses direction of movement for a predetermined distance or time such as, for example, a percentage of the distance or time traveled since the first obstruction.

Motor Power Based Detection For motor power based detection, one or more current sensors **74** are suitably mounted on the pedal assembly **10** in a manner that allows the controller **70** to monitor the electric current delivered to the electric motor **60** used to move the control pedals **12***a*, **12***b*. The sensor **74** is mounted either directly on the electric motor **60** or elsewhere in the assembly **10** in a manner that allows the controller **70** to determine rotational velocity of the electric motor **60**. The output torque of a permanent magnet dc motor can be approximately determined using the relationship $T=KI$, where T is the output torque of the electric motor **60**, K is the motor torque constant for the particular electric motor **60**, and I is the motor current. The instantaneous power supplied by the electric motor **60** can be determined by the relationship $P=Tw$, where P is the output power of the electric motor **60**, T is the motor torque, and w is the instantaneous angular velocity of the electric motor **60**.

The controller **70** selectively powers the electric motor **60** to move the control pedals **12***a*, **12***b* in a fore or aft direction. After applying power to the motor **60**, the controller **70** waits a predetermined period of time to allow the motor **60** to reach its normal operating power. Alternatively, the controller **70** monitors the power and determines, based on predetermined criteria, when the normal operating power has been obtained. The normal operating power will change as environmental conditions change and as the system wears over time. The controller **70** then stores/records the this motor power value. If the initial recorded power value is outside of some predetermined or pre-calculated range, the controller **70** stops the electric motor **60**. Alternatively, the controller **70** can stop the electric motor **60** and reapply power to the motor **60** so that the control pedals **12***a*, **12***b* move in the opposite direction for some predetermined time or distance.

If the motor power value is within a predetermined or pre-calculated range, the controller **70** continues to determine the motor power, and each time compares it to the original stored value, as the control pedals **12***a*, **12***b* move. If the motor power is ever higher or lower than the original motor power by some predetermined or pre-calculated range, the controller **70** stops the electric motor **60**. Alternatively, the controller **70** can stop the electric motor **60** and reapply power to the motor **60** so that the pedals move in the opposite direction for some predetermined time or distance. Alternatively, if the motor power value is within the predetermined or pre-calculated range, the controller **70** continues to measure and record motor power, each time comparing the current value to the previously recorded value. If the power increases or decreases by more than a predetermined or pre-calculated range, the controller **70** stops the electric motor **60**. Alternatively, the controller **70** can stop the electric motor **60** and reapply power to the motor **60** so that the pedals move in the opposite direction for some predetermined time or distance. If a second obstruction is encountered upon reversing direction, the controller **70** places the system in fault mode and stops the motor **60** and/or again reverses direction of movement for a predetermined distance or time such as, for example, a percentage of the distance or time traveled since the first obstruction.

The motion information from the sensors **74** can also be utilized to return the control pedals **12***a*, **12***b* to a stored preferred location (a stored number of pulses from the home position) when selected by the driver. The driver adjusts the control pedals **12***a*, **12***b* to a preferred location and engages one of the memory switches **86**, **88** for a predetermined period of time which is preferably verified by the indicator device **84**, such as by a flash of the indicator light, so that the preferred location is saved in memory. At a later time, when the driver engages the same memory switch **86**, **88** the controller **70** automatically activates the motor **60** to rotate the drive screws **54** and move the control pedals **12**_a_, **12**_b_ from the current position (a known number of pulses from the home position) to the saved position (a stored number of pulses from the home position). The controller **70** automatically stops the motor **60** when the motion information from the sensors **74** that the necessary number of pulses, in the necessary direction, have occurred to reach the stored position.

Each control pedal **12**_a_, **12**_b_ preferably includes a separate sensor **74** so that motion information is obtained regarding each of the drive screws **54**. By having motion information regarding each drive screw **54**, the controller **70** can identify when the control pedals **12**_a_, **12**_b_, are not moving in the same manner, that is maintaining the same relationship to each other. Preferably, the controller **70** deactivates the motor **60** if there is an indication that a predetermined relationship between two or more of the control pedals **12**_a_, **12**_b_ is not maintained. For example, the predetermined relationship can be the step over of the brake and accelerator pedals. If the sensors **74** indicate a change in relationship between the control pedals **12**_a_, **12**_b_, the controller **70** places the system in fault mode. Preferably the indicator device **84** identifies that the system **14** is in fault mode such as, for example, by blinking the indicator light.

The controller **70** is preferably adapted to selectively trigger an initialization process to identify where the control pedals **12**_a_, **12**_b_ are located. This initialization process can be utilized at start up after any loss of power, such as a battery change, and/or after a system shut down due to failure detection or fault mode. When the initialization process is triggered, the controller **70** activates the motor **60** to move the drive nuts **58** forward until they reach the forward or home hard stop. The controller **70** then reverses the motor **60** to move the drive nuts **58** in a rearward direction until they reach the rearward or travel hard stop. The controller **70** compares the distance between the located hard stops, or alternatively the determined soft stops, to determine if an artificial hard stop or obstruction was engaged. If the distance is adequate, the controller **70** sets the soft stops a predetermined distance from the located hard stops. If the distance is not adequate, that is it indicates an obstruction was engaged, the controller **70** places the system in fault mode. Preferably the indicator device **84** identifies that the system **14** is in fault mode such as, for example, blinking the indicator light.

It is noted that the LED can blink at different rates depending on the type of failure such as, for example, a one second rate for a step over failure, a two second rate for an initialization failure, a 0.25 second rate for a temporary fault in the circuit such as an H-bridge. Preferably, means are provided for resetting or initializing the system **14** when in fault mode such as, for example, a reset switch. In the preferred embodiment, the reset or initialization process is triggered by engaging the forward switch **80** and each of the memory switches **86**, **88** simultaneously.

FIGS. **7**A to **13**B illustrate flow charts for preferred operation of the controller **70**. The initialization program loop or routine is best shown in FIGS. **7**A to **7**C. The controller **70** runs a “find pedal hard stops routine” when the initialization process is triggered. The find pedal hard stops routine is described in more detail hereinbelow with regard to FIGS. **10**A and **10**B. If the hard stops are not found, the system **14** is placed in fault mode and the LED light **84** is blinked at a predetermined rate such as two seconds on and two seconds off. If the hard stops are found, the soft stops are then determined by the controller **70**. Preferably, the home soft stop location is determined by adding a predetermined distance (predetermined number of pulses) from the home hard stop. The travel soft stop is determined by subtracting the home soft stop location (number of pulses from the home hard stop) from the from the travel hard stop location (number of pulses from the home hard stop). The distance between the travel and home soft spots is compared to a predetermined distance to determine if an artificial hard stop or obstacle was engaged. If an obstacle was engaged, the system **14** is placed in fault mode and the LED light **84** is blinked at a predetermined rate such as two seconds on and two seconds off. If an obstacle was not engaged, stored memory positions for the memory switches **86**, **88** are set to the home soft stop and the control pedals **12**_a_, **12**_b_ are moved between the travel soft stop and the home soft stop. If a stall or obstruction is detected during this movement, the system **14** is placed in fault mode and the LED light **84** is blinked at a predetermined rate, such as two seconds on and two seconds off. If a stall or obstruction is not detected during this movement, the two pedal positions are set equal and the main program loop is initiated.

The main program loop is best shown in FIGS. **8**A to **8**C. When an ignition switch of the motor vehicle is detected to be off, the controller **70** checks for a step over fault condition (the two control pedals are no longer at equal positions). If a step over fault condition is determined, the system **14** is placed in fault and the LED light **84** is blinked at a predetermined rate such as one second on and one second off. If the user attempts to reset the system **14**, the initialization process of FIGS. **7**A to **7**C is initiated. If a step over fault condition is not detected, the controller **70** checks for an H-bridge or circuit fault condition. If a circuit fault condition is determined, the system **14** is placed in fault and the LED light **84** is blinked at a predetermined rate such as a quarter of a second on and a quarter of a second off. The controller **70** continues to check if the condition remains and clears the fault state when the condition no longer exists. If a circuit fault condition is not detected and the forward switch **80** or the rearward switch **82** is pressed for at least a predetermined period of time, such as more than ten milliseconds, the move pedal routine (FIGS. **11**A to **11**C) is initiated after properly setting the direction to forward or rearward depending on which direction switch **80**, **82** was pressed. If a circuit fault condition is not detected and the first memory switch **86** or the second memory switch **88** is pressed for at least a predetermined period of time, such as more than ten milliseconds, the memory button routine (FIGS. **9**A and **9**B) is initiated after properly setting the button number to 1 or 2 depending on which memory switch **86**, **88** was pressed. After completing the memory routine, the move pedal routine is initiated.

The memory button program loop or routine is best shown in FIGS. **9**A and **9**B. If the memory switch **86**, **88** is released prior to a predetermined period of time, such as two seconds, memory movement is enabled. The controller **70** determines the difference between the current pedal position and the desired memory position (number of pulses). If the current pedal position is greater than the memory position, the movement direction is set to forward and the move pedal routine is initiated. If the current pedal position is less than the memory position, the movement direction is set to rearward and the move pedal routine is initiated. If the memory switch **86**, **88** is not released prior to the predetermined period of time, such as two seconds, the current pedal position (number of pulses from the home position) is saved into the memory position of the memory switch **86**, **88** that was pressed by the operator and the LED **84** is blinked for a predetermined period of time such as 250 milliseconds.

The find pedal hard stop program loop or routine is best shown in FIGS. **10**A and **10**B. Initially, the movement set point, that is the current position, is set to zero and the movement direction is set to forward. The move pedal routine is initiated to move the control pedals **12***a*, **12***b* in the forward direction for a number of pulses which ensures that the forward hard stop will be engaged. When a stall is detected, the two pedal positions are set to zero because they are at the home hard stop. The movement direction is set to rearward and the move pedal routine is initiated to move the control pedals **12***a*, **12***b* in the rearward direction for a number of pulses which ensures that the rearward hard stop will be engaged. When a stall is detected, the travel hard stop is set and the controller **70** returns to the initialization routine.

The move pedal program loop or routine is best shown in FIGS. **11**A to **13**B. Initially, previous and saved pulse width counts are set to zero. The hall-effect sensor **74** of the first control pedal **12***a* is monitored to determine the state of the sensor pulses (high or low). Each time there is a transition in output from the sensor **74**, from either low to high or high to low, the pulse count indicating the current position of the first pedal **12***a* is incremented or decremented depending on the direction of travel. The hall-effect sensor **74** of the second control pedal **12***b* is monitored in the same manner. With the pulse counts indicating the current position of each of the control pedals **12***a*, **12***b* being continuously updated, the controller **70** can determine whether the pulse count indicating the current position is equal to the set point indicating a desired position. When a set point is reached, the movement is complete.

During the move pedal routine, the controller **70** continuously checks for various conditions which indicate movement should be stopped. For example, the controller **70** determines if the home soft stop has been reached if traveling in the forward direction and if the travel soft stop has been reached in traveling in the rearward direction. If a soft stop is reached, movement is complete. The controller **70** also determines if a stall condition is present. If a stall condition is detected, movement is stopped and/or reversed. The controller **70** further determines if there is a step over error, that is the first and second control pedals **12***a*, **12***b* are not in the same current position. If there is a step-over error, movement is complete. The move routine continues to loop until the movement is complete or the direction switch **80**, **82** is released by the operator and the controller stops the motor **60**.

During movement of the control pedals **12***a*, **12***b*, rotation of the motor **60** rotates the drive screw **54** through the drive cable **62** and causes the drive nut **58** to axially move along the drive screw **54** in the desired direction. The drive nut **58** moves along the drive screw **54** because the drive nut **58** is held against rotation with the drive screw **54** by the lower guide pin **50**. As the drive nut **58** axially moves along the drive screw **54**, the lower guide pin **50** moves along the lower slots **40** because the lower guide pin **50** is secured to the drive nut **58**. It is noted that binding of the drive nut **58** along the drive screw **54** is minimized if a self-aligning joint is provided, between the drive screw **54** and the drive screw housing **56** and/or the drive nut **58** and the lower guide pin **50**, to automatically align the components so that the drive nut **58** can smoothly travel along the drive screw **54**. As the lower guide pin **50** slidingly moves along the lower slots **40**, the lower pedal arm **22** is moved therewith to adjust the forward/rearward position of the pedal **24**. As the lower pedal arm **22** moves, the upper guide pin **48** slides along the upper slots **38**. With such movement, the pedal **24** travels in a substantially linear and horizontal path, that is, the pedal **24** moves in a forward/rearward direction and generally remains at the same height relative to the fixed mounting bracket **28** and the upper pedal arm **16** which does not move relative the mounting bracket **28** during adjustment of the pedal **24**. The lower pedal arm **22** pivots as it moves so that the orientation of the pedal **24** slightly changes. This change in orientation of the pedal **24** is typically too small to be detected by the motor vehicle operator. As the position of the pedal **24** is adjusted by rotating the drive screw **54**, the upper pedal arm **16** remains in fixed position relative to the mounting bracket **28**. It can be seen from the above description that activation of the motor **60** changes the position of the lower pedal arm **22** relative to the upper pedal arm **16** and the position of the pedal **24** relative to the motor vehicle operator but not the position of the upper pedal arm **16** relative to the mounting bracket **28** and therefore does not affect the connection of the upper pedal arm **16** to the control device of the motor vehicle through the booster pin **42**.

From the foregoing disclosure and detailed description of certain preferred embodiments, it is also apparent that various modifications, additions and other alternative embodiments are possible without departing from the true scope and spirit of the present invention. For example, it is apparent to those skilled in the art, given the benefit of the present disclosure, that the sensors **74** can have many different forms, quantities, and locations. The embodiments discussed were chosen and described to provide the best illustration of the principles of the present invention and its practical application to thereby enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the present invention as determined by the appended claims when interpreted in accordance with the benefit to which they are fairly, legally, and equitably entitled.

What is claimed is:

1. An adjustable pedal assembly comprising, in combination:

a carrier;

a lower arm supported by the carrier and operatively connected to the carrier for selected movement relative to the carrier;

a drive assembly operatively connected to the lower arm to selectively move the lower arm relative to the carrier, the drive assembly comprising a drive screw connected to one of the lower arm and the carrier, a drive nut connected to the other of the lower arm and the carrier and cooperating with the drive screw such that the drive nut travels along the drive screw upon rotation of the drive screw to move the lower arm, and an electric motor operatively connected to the drive screw to selectively rotate the drive screw;

a sensor to detect motion information indicating movement of the lower arm upon rotation of the drive screw;

a controller connected to the motor to selectively activate and deactivate the motor and connected to the sensor to receive the motion information from the sensor, the controller having a processor programmed to selectively active the motor to move the lower arm, to receive the motion information, and to determine obstruction conditions of the lower arm based on the motion information during movement of the lower arm; and

wherein the motion information includes velocity information, and obstruction conditions are determined based on the velocity information.

2. The adjustable pedal assembly according to claim **1**, wherein the processor is programmed to determine an obstruction condition by comparing a current speed value with a stored full speed value.

3. The adjustable pedal assembly according to claim **2**, wherein the controller has memory and the processor is programmed to store a new full speed value in the memory during each movement of the lower arm.

4. The adjustable pedal assembly according to claim **2**, wherein the processor is programmed to determine an obstruction condition by comparing the current speed value with a sum of the stored full speed value and a constant value.

5. The adjustable pedal assembly according to claim **1**, wherein the sensor is one of a hall-effect switch, a potentiometer, a linear hall-effect device, a linear potentiometer, and a current shunt.

6. The adjustable pedal assembly according to claim **4**, wherein the constant value is a predetermined percentage of the stored full speed value.

7. The adjustable pedal assembly according to claim **1**, wherein the sensor is located adjacent the drive screw.

8. The adjustable pedal assembly according to claim **1**, wherein the processor is programmed to stop movement of the lower arm when an obstruction condition is detected between limits of travel of the lower arm.

9. An adjustable pedal assembly comprising, in combination:

a carrier;

a lower arm supported by the carrier and operatively connected to the carrier for selected movement relative to the carrier;

a drive assembly operatively connected to the lower arm to selectively move the lower arm relative to the carrier, the drive assembly comprising a drive screw connected to one of the lower arm and the carrier, a drive nut connected to the other of the lower arm and the carrier and cooperating with the drive screw such that the drive nut travels along the drive screw upon rotation of the drive screw to move the lower arm, and an electric motor operatively connected to the drive screw to selectively rotate the drive screw;

a sensor to detect motion information indicating movement of the lower arm upon rotation of the drive screw; and

a controller connected to the motor to selectively activate and deactivate the motor and connected to the sensor to receive the motion information from the sensor, the controller having a processor programmed to selectively active the motor to move the lower arm, to receive the motion information, and to determine obstruction conditions of the lower arm based on the motion information during movement of the lower arm; and

wherein the motion information includes acceleration information, and obstruction conditions are determined based on the acceleration information.

10. An adjustable pedal assembly comprising, in combination:

a carrier;

a lower arm supported by the carrier and operatively connected to the carrier for selected movement relative to the carrier;

a drive assembly operatively connected to the lower arm to selectively move the lower arm relative to the carrier, the drive assembly comprising a drive screw connected to one of the lower arm and the carrier, a drive nut connected to the other of the lower arm and the carrier and cooperating with the drive screw such that the drive nut travels along the drive screw upon rotation of the drive screw to move the lower arm, and an electric motor operatively connected to the drive screw to selectively rotate the drive screw;

a sensor to detect motion information indicating movement of the lower arm upon rotation of the drive screw; and

a controller connected to the motor to selectively activate and deactivate the motor and connected to the sensor to receive the motion information from the sensor, the controller having a processor programmed to selectively active the motor to move the lower arm, to receive the motion information, and to determine obstruction conditions of the lower arm based on the motion information during movement of the lower arm; and

wherein the motion information includes motor current information, and obstruction conditions are determined based on the motor current information.

11. An adjustable pedal assembly comprising, in combination:

a carrier;

a lower arm supported by the carrier and operatively connected to the carrier for selected movement relative to the carrier;

a drive assembly operatively connected to the lower arm to selectively move the lower arm relative to the carrier, the drive assembly comprising a drive screw connected to one of the lower arm and the carrier, a drive nut connected to the other of the lower arm and the carrier and cooperating with the drive screw such that the drive nut travels along the drive screw upon rotation of the drive screw to move the lower arm, and an electric motor operatively connected to the drive screw to selectively rotate the drive screw;

a sensor to detect motion information indicating movement of the lower arm upon rotation of the drive screw; and

a controller connected to the motor to selectively activate and deactivate the motor and connected to the sensor to receive the motion information from the sensor, the controller having a processor programmed to selectively active the motor to move the lower arm, to receive the motion information, and to determine obstruction conditions of the lower arm based on the motion information during movement of the lower arm; and

wherein the motion information includes motor power information, and stall conditions are determined based on the motor power information.

12. An adjustable pedal assembly comprising, in combination:

a carrier;

a lower arm supported by the carrier and operatively connected to the carrier for selected movement relative to the carrier;

a drive assembly operatively connected to the lower arm to selectively move the lower arm relative to the carrier, the drive assembly comprising a drive screw connected to one of the lower arm and the carrier, a drive nut connected to the other of the lower arm and the carrier and cooperating with the drive screw such that the drive nut travels along the drive screw upon rotation of the drive screw to move the lower arm, and an electric motor operatively connected to the drive screw to selectively rotate the drive screw;

a sensor to detect motion information indicating movement of the lower arm upon rotation of the drive screw; and

a controller connected to the motor to selectively activate and deactivate the motor and connected to the sensor to receive the motion information from the sensor, the controller having a processor programmed to selectively active the motor to move the lower arm, to receive the motion information, and to determine obstruction conditions of the lower arm based on the motion information during movement of the lower arm; and

wherein the sensor is a current sensor.

13. An adjustable pedal assembly comprising, in combination:

a carrier;

a lower arm supported by the carrier and operatively connected to the carrier for selected movement relative to the carrier;

a drive assembly operatively connected to the lower arm to selectively move the lower arm relative to the carrier, the drive assembly comprising a drive screw connected to one of the lower arm and the carrier, a drive nut connected to the other of the lower arm and the carrier and cooperating with the drive screw such that the drive nut travels along the drive screw upon rotation of the drive screw to move the lower arm, and an electric motor operatively connected to the drive screw to selectively rotate the drive screw;

a sensor to detect motion information indicating movement of the lower arm upon rotation of the drive screw; and

a controller connected to the motor to selectively activate and deactivate the motor and connected to the sensor to receive the motion information from the sensor, the controller having a processor programmed to selectively active the motor to move the lower arm, to receive the motion information, and to determine obstruction conditions of the lower arm based on the motion information during movement of the lower arm; and

wherein the processor is programmed to reverse direction of movement of the lower arm when an obstruction condition is detected between limits of travel of the lower arm.

14. The adjustable pedal assembly according to claim **13**, wherein the processor is programmed to reverse direction of movement of the lower arm for a predetermined distance when the obstruction condition is detected.

15. The adjustable pedal assembly according to claim **13**, wherein the processor is programmed to reverse direction of movement of the lower arm for a predetermined period of time when the obstruction condition is detected.

16. The adjustable pedal assembly according to claim **13**, wherein the processor is programmed to stop movement of the lower arm when another obstruction condition is detected after reversing direction of movement of the lower arm upon detecting the obstruction condition.

17. The adjustable pedal assembly according to claim **13**, wherein the processor is programmed to again reverse direction of movement of the lower arm for a predetermined distance when another obstruction condition is detected after reversing direction of movement of the lower arm upon detecting the obstruction condition.

18. The adjustable pedal assembly according to claim **13**, wherein the processor is programmed to again reverse direction of movement of the lower arm for a predetermined period of time when another obstruction condition is detected after reversing direction of movement of the lower arm upon detecting the obstruction condition.

19. An adjustable pedal assembly comprising, in combination:

a carrier;

a lower arm supported by the carrier and operatively connected to the carrier for selected movement relative to the carrier;

a drive assembly operatively connected to the lower arm to selectively move the lower arm relative to the carrier, the drive assembly comprising a drive screw connected to one of the lower arm and the carrier, a drive nut connected to the other of the lower arm and the carrier and cooperating with the drive screw such that the drive nut travels along the drive screw upon rotation of the drive screw to move the lower arm, and an electric motor operatively connected to the drive screw to selectively rotate the drive screw;

a sensor to detect motion information indicating movement of the lower arm upon rotation of the drive screw; and

a controller connected to the motor to selectively activate and deactivate the motor and connected to the sensor to receive the motion information from the sensor, the controller having a processor programmed to selectively active the motor to move the lower arm, to receive the motion information, and to determine obstruction conditions of the lower arm based on the motion information during movement of the lower arm; and

wherein the processor is programmed to determine stall conditions of the lower arm in both forward and rearward directions.

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